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# SPACE STATION BUSINESS

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Also:

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TEXAS INSTRUMENTS

Larger power requirements of advanced satellites promise to be met by a new type of battery. Hughes Aircraft Company is developing nickel-hydrogen technology for the U.S. Air Force. The new batteries will be placed on larger spacecraft now being built for customers such as the Air Force, Japan Communications Satellite Company, and INTELSAT, the internal communications consortium. A nickel-hydrogen battery the same size and weight of a conventional nickel-cadmium battery will produce more watts for more years, take more abuse, and perform well even when nearly drained of power.

Hot spots, leaks, and other potential problems in jet engines show up more readily during testing with the use of a Probeye® thermal video system by the U.S. Air Force. Six units of an advanced, third-generation version of the system, developed by Hughes, have been delivered to Arnold Air Force Station in Tennessee for use in analyzing engines undergoing performance testing. Designed for both laboratory and field applications, the all-electric thermography system provides a real-time, multi-color television display of the temperature distribution of a scene being viewed by the Probeye infrared viewer. The new version features enhanced image processing capability, a four-fold improvement in resolution, easier portability and other operational improvements that provide the user with more information for quicker, more accurate testing.

U.S. Army's Fiber Optic Guided Missile (FOG-M) uses a new winding technology to deploy its plastic-coated glass fiber. This fiber permits a two-way jam-proof communication link for transmission of television-like pictures of enemy armor and helicopters to a gunner station located in a protected position. Using technologies learned from 20 years of producing Tube-launched, Optically tracked, Wire-guided (TOW) missiles, Hughes engineers developed a method of precisely winding optical strands so that they can be dispensed at missile velocities without interruption of the data transmission. Because the optical fibers are not much larger than the thickness of a strand of human hair and are elastic and pliable, Hughes invented a device which precisely measures the elasticity of each fiber thus allowing it to be spool-wound with precision. Another Hughes technological advancement is a diagnostic instrument that detects defects in the fiber.

A flight engineering simulator will help develop new military aircraft and systems as well as improve existing ones. The system will be operated by General Dynamics, which produces the F-16 fighter for the U.S. Air Force. The simulator will help serve as proof that design concepts are feasible and allow comparisons to be made without risk of substantial capital investment. It will use technology from F/A-18 training systems developed for the U.S. Navy and Marine Corps. Hughes will supply an image generation and display system, plus operator control and equipment monitoring hardware. The simulator will include 40-foot domes, each housing General Dynamics cockpits and avionics systems.

A broad spectrum of technologies, many of which grew up within the past five years, are represented in the products of Hughes' Industrial Electronics Group. Six divisions and two subsidiaries, each operated like a small high-tech company but backed by resources of its multibillion-dollar parent, offer career benefits to qualified engineers and scientists. Advancing technologies such as microwave and millimeter-wave communications, silicon and GaAs solid-state circuitry, fiber optics, and image processing equipment are pursued in facilities located in many of Southern California's most desirable coastal communities. Send your resume to A.T. Moyer, Hughes Industrial Electronics Group, Dept. S2, P.O. Box 2999, Torrance, CA 90509. EOE. U.S. citizenship may be required.

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## FEATURES



## DEPARTMENTS



**Cover** Boeing Aerospace president Mark Miller with a model of a pressurized module for the U.S. space station. Photo by Louis Bencze.

EDITOR'S NOTE

# INSIDE THE BUSINESS OF SPACE

In a few months, NASA will select the companies that will build the first U.S. space station. The money being spent is an indication of just how much is at stake for both winners and losers. In this month's cover story (see **"Space Station Business,"** page 10), we look at the business behind the space station and identify the companies poised to prosper because of it.

The list of companies going after contracts reads like a Who's Who in aerospace. It's Boeing against Martin Marietta. McDonnell Douglas versus Rockwell. General Electric against RCA. Rocketdyne versus TRW.

Two companies, Boeing and Martin Marietta, have taken an all-or-nothing approach. And "all" in this case adds up to big numbers. Increased demands by the government on potential contractors are upping the ante for firms that want to be in the space business. Boeing says it has spent $72 million in pursuit of the contact, while Martin Marietta says it has invested $24 million. Other bidders are hedging their bets and participating as subcontractors on several different projects to ensure that they have a part of what is one of the biggest projects in aerospace right now.

The rewards are substantial. In addition to the $8 billion worth of work, the successful companies will get a significant presence in the civilian space business and the prestige that comes from so public a project. In some cases, another hidden benefit for the winners is the opportunity to develop technologies and products that can help the companies profit beyond the current contracts.

To assemble the space-business story, staff members contacted all eight lead bidders to determine how the 29 contractors and subcontractors line up in the battle for a piece of the space station. We asked stock analysts to assess the effect the contracts will have on the aeronautics industry. We talked to NASA experts and the companies involved about where the space-station project stands with both Congress and groups that are unhappy with the U.S. space effort. Will it do what it was intended to do? Why was it scaled down so much? What are the implications of the cutback for the space manufacturing business?

And, most importantly, we looked at the impact that winning a contract can have on the successful companies.

Also in this issue, we take a look at the growing market for optical-disk storage (**"Optical Memories Burst onto the Market,"** page 43). We tell you which companies are involved in the fastest-growing segments of the market and which one is expected to reach $4 billion by 1995, thanks to large storage capacity and easy portability.

We also explore the business opportunities in membrane-filtration systems (**"New Filters Clean up in New Markets,"** page 21), a $500-million industry that's growing fast. We tell you which applications have the highest projected growth over the next decade.

We will continue to explore such business opportunities, which could only be made possible by new technology.

In the midst of all this, we have also moved to new offices. Our new address is **214 Lewis Wharf, Boston, MA 02110.** Our new phone number is **(617) 723–6611.** We hope to hear from you.

Charles L. Martin, Jr.


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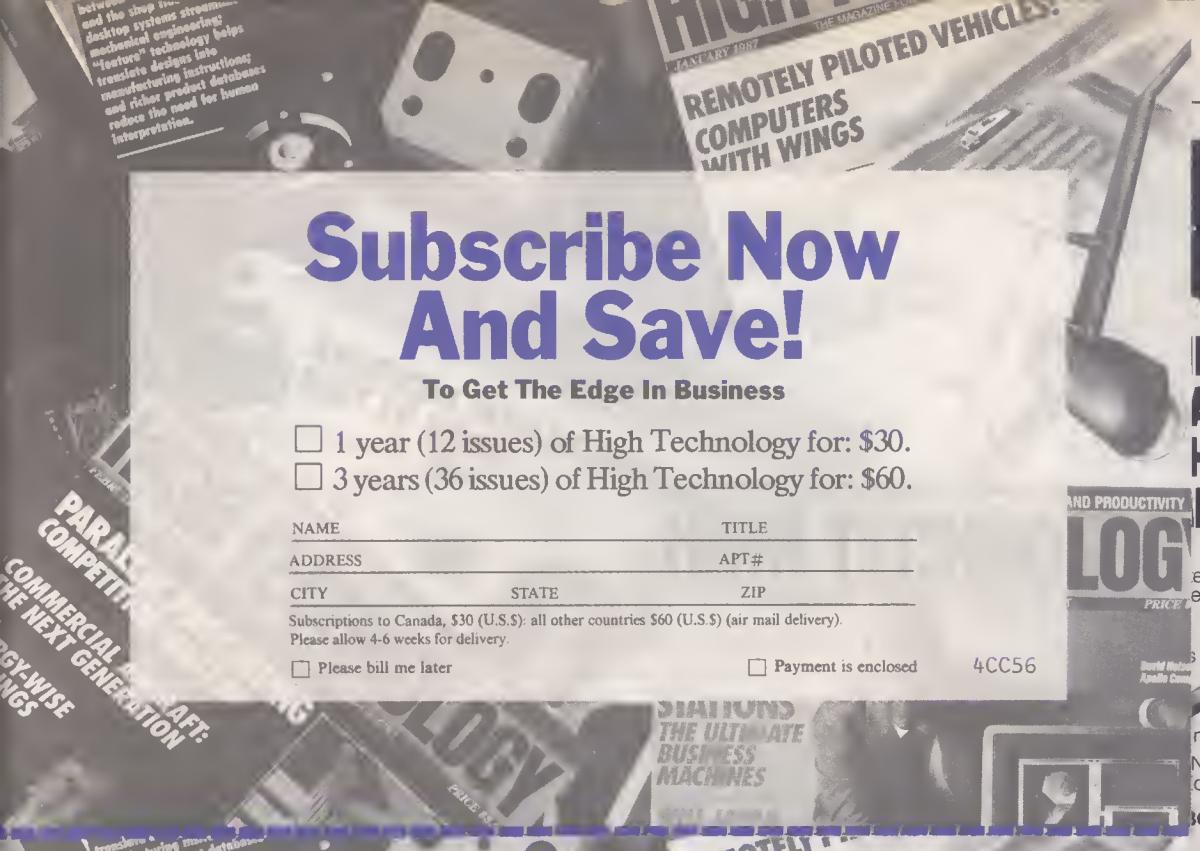





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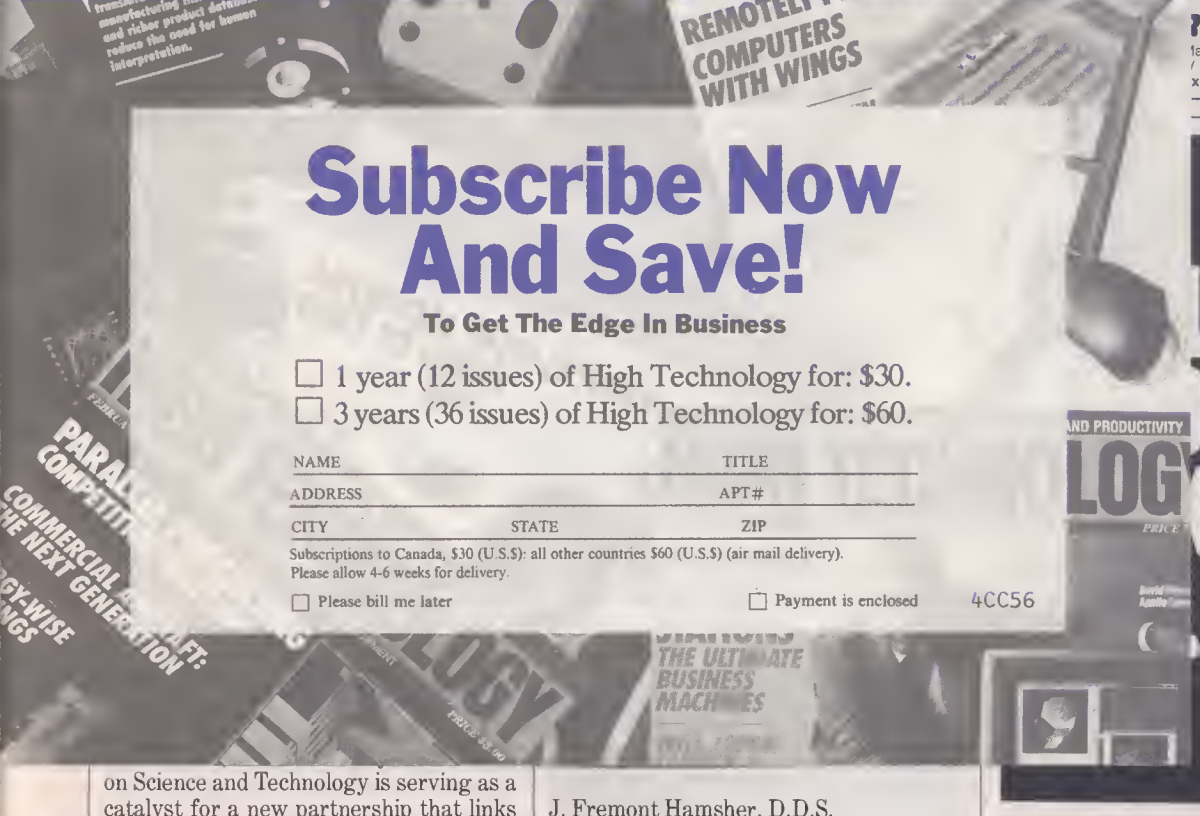




on Science and Technology is serving as a catalyst for a new partnership that links the impressive resources of our private sector with the rapidly expanding research programs at our higher-education institutions. Indeed, it is the commission's express purpose to ensure that as entrepreneurs spin off from Bell Labs, they will be able to draw on the expertise in our Advanced Technology Centers, in fields such as fiber optics, industrial ceramics,

STEVE LYONS

J. Fremont Hamsher, D.D.S.
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We welcome comments from our readers. Please address letters to Editor, High Technology, 214 Lewis Wharf, Boston, MA 02110, (617) 723-6611. Or send to MCI Mailbox: HIGHTECHLET 262-6468.

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**PRESIDENT/CHIEF EXECUTIVE OFFICER**
Mark J. Estren


## New Jersey encourages high tech

Your recent article, "Bell Labs Spinoffs" (June 1987), only made passing note of the fact that the overwhelming majority of the firms started by the entrepreneurial alumni of this respected research facility stay in New Jersey.

Of the 11 spinoffs noted in the article, eight are in New Jersey. It is no coincidence that those who leave AT&T Bell Laboratories to launch their own businesses choose to remain in the state. When you consider that New Jersey leads the country in privately funded research—nearly 11 percent of the nation's total R&D dollars are spent here—and that one-tenth of all U.S. patents are issued to New Jersey inventors, one can better understand why many entrepreneurs in advanced technologies regard the state as the hotbed of leading-edge research and development.

The state's leadership role in new technologies, particularly photonics–fiber optics, is made possible not only by the exceptional researchers at Bell Labs' several centers in New Jersey, but also through the talented researchers at such facilities as Bell SRI/David Sarnoff Research Laboratories in Princeton, GE/RCA in southern New Jersey, Siemens Research Technology Laboratory in Princeton, Allied Signal in Mount Bethel, and Exxon Research and Engineering Laboratory in Annandale.

Moreover, the New Jersey Commission on Science and Technology is serving as a catalyst for a new partnership that links the impressive resources of our private sector with the rapidly expanding research programs at our higher-education institutions. Indeed, it is the commission's express purpose to ensure that as entrepreneurs spin off from Bell Labs, they will be able to draw on the expertise in our Advanced Technology Centers, in fields such as fiber optics, industrial ceramics, telematics, and supercomputing.

We fully understand your appreciation of the extraordinary importance of Bell Labs' continuing stimulation of commercially significant technology. We in New Jersey count ourselves fortunate that Bell Labs and many other such outstanding industrial laboratories are located in our state and consistently contribute to our technological development.

Edward Cohen
Executive Director
New Jersey Commission on
Science and Technology
Trenton, N.J.

## New dentistry may solve old problem

I was very interested to read your story about the use of new dental techniques and substances in the July issue of HIGH TECHNOLOGY. So many stories have appeared about the plight of dentists in the age of fluoridation and better preventive care that we sometimes feel like an endangered species. It was gratifying that a magazine of HIGH TECHNOLOGY's caliber took note of the fact that there are still many areas in which dentists can help the public by doing more than simply filling cavities visit after visit.

I also was particularly pleased to see the discussion of the caries-removal chemical that dissolves decayed areas without the need for drilling. Unfortunately, too many people are still reluctant to see a dentist unless forced to do so by the very pain they are trying so desperately to avoid. Perhaps this technique and other new methods developed to reduce or eliminate the painful aspects of older forms dental care will encourage people to pay as much attention to their dental fitness as to aerobics and other forms of self-improvement.

J. Fremont Hamsher, D.D.S.
Laguna Niguel, Cal.

We welcome comments from our readers. Please address letters to Editor, High Technology, 214 Lewis Wharf, Boston, MA 02110, (617) 723–6611. Or send to MCI Mailbox: HIGHTECHLET 262–6468.

STEVE LYONS

# NEW DEVELOPMENTS

## Superconductor race accelerates

The mercury is still rising on the superconductor scene. Researchers are now reporting tantalizing evidence of materials that lose all resistance to electrical current at temperatures far higher than was thought possible only months ago. The road to room-temperature superconducting has turned out to be rockier than early laboratory breakthroughs suggested, though.

Conventional superconductors work only when cooled to about –460° F and thus must be bathed in liquid helium, which is costly and difficult to handle. Ultimately, superconductors that require little or no refrigeration might be used in ultrafast electronic chips, continent-spanning electrical-power lines, and levitated trains.

Leading physicists are finding that warm-weather superconductivity can be elusive. University of Houston pathfinder Paul Chu reached –54° F, but the phenomenon disappeared after the test sample was repeatedly warmed and cooled. Similarly unstable results with the same class of materials (copper-oxide ceramics) have come out of the University of California (Berkeley), Stanford (Palo Alto, Cal.), and Wayne State (Detroit). And at Energy Conversion Devices (Troy, Mich.), chief scientist Stephen Hudgens claims to have measured glimmers of superconductivity at *positive* 45° F, but he has been unable to reproduce this result.

Much work lies ahead in turning laboratory breakthroughs into production technology. "These materials require the knowledge of a master chef," says Phillip Parish, head of materials-science research at the Defense Advanced Research Projects Agency (DARPA—Arlington, Va.). "Sometimes things get out of hand, and you get airline food." DARPA is putting tens of millions of dollars into a superconductor program in fiscal 1988, according to deputy director Craig Fields. The goal: pilot production lines that in three to four years will start turning out wire, tape, and thin film made from the new superconductors.

Argonne National Laboratory (Argonne, Ill.) has taken the lead in forming wires from the ceramic superconductors. Argonne has produced fibers 0.005 of an inch in diameter—thin enough to be twisted into a flexible cable. However, so far these fibers can carry only small amounts of current—200 amperes per square centimeter in the presence of strong magnetic fields. To make the superconducting wires commercially useful, reports Roger Poepple, who is managing Argonne's work, a fiftyfold improvement will be needed.

## New Water System Cuts Filtering Cost

By combining an energy-recovery system and artificial-intellegence programming with a well-established desalination process, the Boston-based start-up Reliable Water claims it can dramatically cut the costs of purifying seawater. Company founder and chairman Edward Fredkin demonstrated the system's effectiveness by drinking Boston Harbor water—some of the most polluted in the nation—after it had passed through a prototype that can produce 1200 potable gallons per day.

The company's first commercial systems, due in early 1988, will have capacities of 30,000–35,000 gallons. Fredkin, a computer scientist and former MIT professor, estimates that the annual worldwide market for desalination plants exceeds $1 billion, with the Arabian Peninsula making up about 60 percent of it.

*Reliable Water's Edward Fredkin plans to profit by making seawater potable.*

RELIABLE WATER COMPANY, INC.

Reliable Water uses a standard reverse-osmosis filtering process (see "New Filters Clean up in New Markets," page 21), in which pressurized seawater is forced against a permeable membrane that traps salt and other impurities while letting water through. To increase the system's efficiency, a patented process recovers 80 percent or more of the energy stored in the pressurized waste brine. The method requires millisecond-by-millisecond control, which is achieved by an expert computer system that monitors and adjusts the process. Although this sophistication makes the system more expensive than existing desalination facilities, the investment is expected to pay off over time because the facility produces pure water at less than one cent per gallon—one-third to two-thirds less than competitive methods.

## Card monitors X-ray exposure

Personal Monitoring Technologies (Rochester, N.Y.) has developed the credit-card-sized CompRad Radiation Health Monitor, a personal watchdog that guards against overexposure to radiation from medical and dental X rays and other sources.

The CompRad card holds four radiation-sensitive dosimeters—similar to the devices radiology technicians use to measure personal exposure. Three dosimeters are removable so they can measure radiation during separate X-ray procedures. The fourth dosimeter remains on the card to record environmental radiation. After the three removable dosimeters have been exposed—or when one year has elapsed—the card is sent to Personal Monitoring Technologies to be analyzed and recorded in the company's data base. Cardholders receive reports comparing their radiation exposure to typical levels. This information, updated each time a card is returned, establishes an ongoing, lifelong history of radiation exposure.

"There is no question that X rays remain one of our most valuable diagnostic tools," explains Derace Schaffer, a Har-

vard-trained radiologist and founder of Personal Monitoring Technologies, "but there reaches a point where too much of a good thing can be bad." The use of X rays is increasing dramatically: Between 1970 and 1980, medical X rays increased by 32 percent and dental X rays by 50 percent, a time when the population grew by only 11 percent.

The card will be of special benefit, Schaffer says, to victims of ileitis, colitis, scoliosis, and arthritis, and to anyone else whose care requires routine X rays.

## Herpes DNA probe is nonradioactive

DNA probe technology has been used to detect herpes virus for the last five years, and most of these probes use radioactive markers. Now Enzo Biochem (New York City) has received Food and Drug Administration approval to sell a nonradioactive DNA probe for the incurable sexually transmitted disease. The company plans to distribute the probe to clinical labs that perform diagnostic tests for hospitals, physicians, and other labs.

Like other DNA probes, the Enzo procedure starts with a sample from the infected area. At the testing lab this smear is heated to split DNA molecules into their two constituent strands. The probe—a customized single strand of DNA that matches a herpes-infected strand—is then added. If any herpes virus is present in the sample it will link up with the synthetic probe. Most probes use a radioactive marker to identify any linked molecules. Enzo's probe, however, is marked with biotin, one of the B vitamins. To make it visible, the enzyme horseradish peroxidase is bound to the biotin. Hydrogen peroxide and a colored dye, added in the last step, create a reaction. The dye is oxidized when the enzyme and the hydrogen peroxide interact, turning a reddish-brown color visible with a microscope.

In 1986 six million herpes tests were performed, says Pat Patrucci, president of Robert S. First (White Plains, N.Y.), health-care management consultants. At a cost of $120–$180 for Enzo's 40-probe kits, the potential market stands at $18 million–$27 million.

MENTOR GRAPHICS:

# EXPANDING ITS EMPIRE IN DESIGN AUTOMATION

In the six years since it was founded, Mentor Graphics (Beaverton, Ore.) has become the dominant player in the field of computer-aided engineering (CAE), marketing workstations and software that automate the design of microprocessors and other integrated circuits. With Hughes Aircraft, Advanced Micro Devices, and Sprague Electric as customers, Mentor claims approximately one-third of last year's $500 million CAE market, compared to 18 percent for Daisy Systems and 11 percent for Valid Logic (which recently merged with Telesis Systems).

Primarily, two strategies have fueled company growth. One is the use of wholly owned, locally staffed subsidiaries to market Mentor's products outside the United States. "It is more expensive to operate this way than through distributors," president Thomas Bruggere says, "but this approach has paid off in our ability to penetrate foreign markets." International sales now comprise almost half of the company's revenues and have helped the company weather the recent slowdown in the domestic market. Particularly notable is Mentor's success in Japan, where the local subsidiary controls 70 percent of the CAE market.

The second and more controversial policy is Mentor's decision not to make its own workstations. Instead, the company uses Domain workstations tailored specially for it by Apollo Computer (Chelmsford, Mass.). Mentor now sells some 25 percent of Apollo's annual output, and the mutual dependence has brought both advantages and problems for the two companies. The connection gives Mentor a ready introduction to Apollo's computer customers, but in return Mentor must rely on an outside company for a significant piece of its product. As for Apollo, Mentor provides another avenue for marketing its workstations; when Mentor stopped ordering machines for nine months in 1985 to work down its inventory, however, Apollo ran into financial difficulties.

*President Thomas Bruggere leads Mentor into a computer-workstation market worth about $7 billion.*

In the past few years Mentor has been reaching beyond CAE for new markets that will build on its current strengths in design automation. For example, in 1984 it introduced computer-aided-design (CAD) products that facilitate the layout of printed circuit boards. Last year, Mentor traded on its reputation for helping engineers document their designs by spinning off Context Corp., in which it retains 80 percent ownership, to tackle the market for desktop publishing systems. Context also offers software that enables engineers to propose changes on a technical document without destroying its original form. A manager can then pick which changes to make.

Down the road for Mentor may lie additional markets in which computers are used as design or simulation tools, including computer-aided testing, electronic packaging, and software engineering. "The present and potential sectors in which we could play a role add up to a $7-billion market," Bruggere says. "By pursuing these arenas, we hope to be a $1-billion company by the nineties." □

*—Dana Blankenhorn*

HEALTHDYNE:

# RECOVERING WITH HOME HEALTH CARE

Healthdyne (Marietta, Ga.) is shifting its product line to capitalize on the emerging market for home health-care products. The $70-million provider of health-care goods and services was hit hard by 1983 Medicare cost-containment legislation that limited hospital and doctor reimbursements and tied length of hospitalization to an illness's "diagnostic-related group."

"Hospital administrators, uncertain about the impact of the new policy on their revenues, stopped buying equipment," says Healthdyne president Parker Petit. They also cut patient time. Between 1983 and 1986 hospital admissions dropped 10 percent, and occupancy fell more than 12 percent, according to the American Hospital Association. At the time of these reductions, half of Healthdyne's sales of infant incubators and other equipment were to hospitals.

Responding to these changes, Healthdyne recently sold its Air Shields hospital-products division, reduced its employees from 2500 in 1984 to 1000, and refocused

RICH IWASAKI

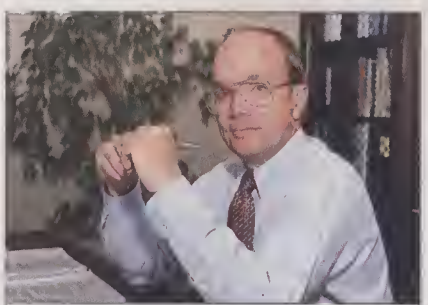
ALCOA:

# TARGETING CERAMICS FOR FUTURE GROWTH

Can a smokestack elephant learn how to swing into the high-tech dance? That's the question confronting Aluminum Co. of America (Alcoa), as the $5-billion company attempts to deal with a slow- or no-growth market in its primary products—refined and semifinished aluminum. The strategic goal, as established several years ago by then-chief executive officer Charles W. Parry, is to transform the 100-year-old company from being an aluminum specialists into a producer of various advanced materials—especially ceramics—and new manufacturing systems that use them. The method will be a combination of selective acquisitions and a nurturing of embryonic businesses.

"Our corporate culture is accustomed to large, capital-intensive projects," spokesman Alfred T. Posti says. "That makes us move a little more slowly than start-ups, but it also means that we have patient capital. We will be able to build new businesses gradually." One new enterprise has already taken root: the Separations Technology Division (STD), which has grown since 1983 from $3 million to more than $120 million in annual sales. Alcoa projects the division will double these revenues in the next five years. STD combines technology developed at Alcoa a half-century ago with three acquisitions: a French ceramic-membrane producer and two well-established water-treatment-systems manufacturers.

The old part of the business is activated alumina, which has been produced as a waste byproduct of aluminum smelting for decades. Treatment with chemicals and heat activates the alumina into a spongelike adsorbent primarily sold as pellets infused with catalyst compounds. "Activated alumina is a traditional product for which we have found new uses," says STD general manager John Starr.



*Separations Technology's John Starr: finding new uses for old products.*

Alcoa's researchers have synthesized the alumina and from it have developed a family of adsorbents, catalyst carriers, chromatographic media, and filtration materials. With the right chemical treatment, the alumina can be used to remove toxic metals from wastewater or contaminants from process fluids. Many of these procedures are currently done by polymeric membranes or filters, but alumina has the advantage of withstanding much higher temperatures (up to 500° C) as well as exposure to acids, bases, and other harsh chemicals. "Although our ceramic membranes may cost three times as much as polymeric membranes," Starr says, "they can work 5–10 times faster and last much longer in harsh process environments."

To commercialize this technology, Alcoa acquired Ceraver, a French firm that markets ceramic membranes under the Membralox brand name. Ceraver will market membranes for concentrating fruit juices, purifying water, cleaning wastewaters, and separating biological materials. Other recent acquisitions have been Illinois Water Treatment (Rockford, Ill.), which makes water purifiers, and Lancy International (Zelionople, Pa.), a wastewater and hazardous-waste treatment firm. "It's more profitable to sell customers a packaged solution to a problem than to sell them a few pounds of speciality adsorbent or filtration media," Starr observes. "The Illinois and Lancy acquisitions enable us to develop specialized separations materials, package them with the necessary pumps, reactors, and control systems, and offer a turnkey processing plant to customers."

Industry observers see STD as a key element of Alcoa's strategy. "It is always possible that STD will be lost in the shuffle at a company as large as Alcoa," says J. Clarence Morrison, senior metals analyst at Dean Witter Reynolds (New York). "But the division is getting a disproportionate share of Alcoa's R&D funds. Its future growth is an important element in Alcoa's plan to become a materials-science enterprise." □

***—Nicholas Basta***

ALCOA

(which recently merged with Telesis Systems).

Primarily, two strategies have fueled company growth. One is the use of wholly owned, locally staffed subsidiaries to market Mentor's products outside the United States. "It is more expensive to operate this way than through distributors," president Thomas Bruggere says, "but this approach has paid off in our ability to penetrate foreign markets." International sales now comprise almost half of the company's revenues and have helped the company weather the recent slowdown in the domestic market. Particularly notable is Mentor's success in Japan, where the local subsidiary controls 70 percent of the CAE market.

The second and more controversial policy is Mentor's decision not to make its own workstations. Instead, the company uses Domain workstations tailored specially for it by Apollo Computer (Chelmsford, Mass.). Mentor now sells some 25 percent of Apollo's annual output, and the mutual dependence has brought both advantages and problems for the two companies. The

in 1985 to work down its inventory, however, Apollo ran into financial difficulties.

In the past few years Mentor has been reaching beyond CAE for new markets that will build on its current strengths in design automation. For example, in 1984 it introduced computer-aided-design (CAD) products that facilitate the layout of printed circuit boards. Last year, Mentor traded on its reputation for helping engineers document their designs by spinning off Context Corp., in which it retains 80 percent ownership, to tackle the market for desktop publishing systems. Context also offers software that enables engineers to propose changes on a technical document without destroying its original form. A manager can then pick which changes to make.

Down the road for Mentor may lie additional markets in which computers are used as design or simulation tools, including computer-aided testing, electronic packaging, and software engineering. "The present and potential sectors in which we could play a role add up to a $7-billion market," Bruggere says. "By pursuing these arenas, we hope to be a $1-billion company by the nineties." □

*—Dana Blankenhorn*

*President Thomas Bruggere leads Mentor into a computer-workstation market worth about $7 billion.*

HEALTHDYNE:

## RECOVERING WITH HOME HEALTH CARE

Healthdyne (Marietta, Ga.) is shifting its product line to capitalize on the emerging market for home health-care products. The $70-million provider of health-care goods and services was hit hard by 1983 Medicare cost-containment legislation that limited hospital and doctor reimbursements and tied length of hospitalization to an illness's "diagnostic-related group."

"Hospital administrators, uncertain about the impact of the new policy on their revenues, stopped buying equipment," says Healthdyne president Parker Petit. They also cut patient time. Between 1983 and 1986 hospital admissions dropped 10 percent, and occupancy fell more than 12 percent, according to the American Hospital Association. At the time of these reductions, half of Healthdyne's sales of infant incubators and other equipment were to hospitals.

Responding to these changes, Healthdyne recently sold its Air Shields hospital-products division, reduced its employees from 2500 in 1984 to 1000, and refocused

RICH IWASAKI

its business on the home-health-care and outpatient-services market, which is booming as hospitalization decreases.

The array of products now supplied by the company includes home monitoring devices for infants and adults as well as home equipment for administering antibiotics, chemotherapy, and other intravenous therapies. Healthdyne's Infusion Therapy Division, for example, produces an intravenous pain-management device that administers morphine or other medication to cancer victims. Instead of receiving periodic injections, patients can use portable infusion pumps to slow-drip the medication into their blood throughout the day. The same technology is being used to administer chemotherapy and AIDS infusion therapy.

The Home Care Products Division has developed a pregnancy monitor that assists doctors in bringing pregnancies to full term. Conventionally, a woman at risk of giving birth prematurely must visit her obstetrician weekly. But Healthdyne's monitor allows a pregnant woman to transmit her contraction rate twice a day by telephone to a central computer. This helps the physicians detect early labor so they can delay premature deliveries—reducing infant mortality and birth defects. The $3000 monitors are usually leased to patients.

To reach the home market, Healthdyne relies on independent home health-care dealers. Hospital-discharge planners, private physicians, and social workers typically prescribe the equipment for their patients, and then these distributors sell or rent it to them.

"We expect to continue developing products that address the cost-containment goals of the legislation," says Petit, who expects to see the fiscal results of Healthdyne's strategy pay off this year. In the first quarter of 1984, soon after the federal legislation went into effect, the company recorded a loss of $450,000. For the first quarter of this year, Healthdyne is off the critical list with reported profits of $500,000. □ ***—Anita Micossi***

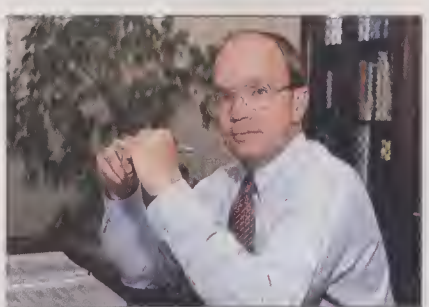
ALCOA:

# TARGETING CERAMICS FOR FUTURE GROWTH

Can a smokestack elephant learn how to swing into the high-tech dance? That's the question confronting Aluminum Co. of America (Alcoa), as the $5-billion company attempts to deal with a slow- or no-growth market in its primary products—refined and semifinished aluminum. The strategic goal, as established several years ago by then-chief executive officer Charles W. Parry, is to transform the 100-year-old company from being an aluminum specialists into a producer of various advanced materials—especially ceramics—and new manufacturing systems that use them. The method will be a combination of selective acquisitions and a nurturing of embryonic businesses.

"Our corporate culture is accustomed to large, capital-intensive projects," spokesman Alfred T. Posti says. "That makes us move a little more slowly than start-ups, but it also means that we have patient capital. We will be able to build new businesses gradually." One new enterprise has already taken root: the Separations Technology Division (STD), which has grown since 1983 from $3 million to more than $120 million in annual sales. Alcoa projects the division will double these revenues in the next five years. STD combines technology developed at Alcoa a half-century ago with three acquisitions: a French ceramic-membrane producer and two well-established water-treatment-systems manufacturers.

The old part of the business is activated alumina, which has been produced as a waste byproduct of aluminum smelting for decades. Treatment with chemicals and heat activates the alumina into a spongelike adsorbent primarily sold as pellets infused with catalyst compounds. "Activated alumina is a traditional product for which we have found new uses,"



***Separations Technology's John Starr: finding new uses for old products.***

says STD general manager John Starr.

Alcoa's researchers have synthesized the alumina and from it have developed a family of adsorbents, catalyst carriers, chromatographic media, and filtration materials. With the right chemical treatment, the alumina can be used to remove toxic metals from wastewater or contaminants from process fluids. Many of these procedures are currently done by polymeric membranes or filters, but alumina has the advantage of withstanding much higher temperatures (up to 500° C) as well as exposure to acids, bases, and other harsh chemicals. "Although our ceramic membranes may cost three times as much as polymeric membranes," Starr says, "they can work 5–10 times faster and last much longer in harsh process environments."

To commercialize this technology, Alcoa acquired Ceraver, a French firm that markets ceramic membranes under the Membralox brand name. Ceraver will market membranes for concentrating fruit juices, purifying water, cleaning wastewaters, and separating biological materials. Other recent acquisitions have been Illinois Water Treatment (Rockford, Ill.), which makes water purifiers, and Lancy International (Zelionople, Pa.), a wastewater and hazardous-waste treatment firm. "It's more profitable to sell customers a packaged solution to a problem than to sell them a few pounds of speciality adsorbent or filtration media," Starr observes. "The Illinois and Lancy acquisitions enable us to develop specialized separations materials, package them with the necessary pumps, reactors, and control systems, and offer a turnkey processing plant to customers."

Industry observers see STD as a key element of Alcoa's strategy. "It is always possible that STD will be lost in the shuffle at a company as large as Alcoa," says J. Clarence Morrison, senior metals analyst at Dean Witter Reynolds (New York). "But the division is getting a disproportionate share of Alcoa's R&D funds. Its future growth is an important element in Alcoa's plan to become a materials-science enterprise." □ ***—Nicholas Basta***

ALCOA

# SPACE STATION BUSINESS

## AEROSPACE COMPANIES SQUARE OFF FOR $8 BILLION

BY PETER GWYNNE

*J. Richard Cook, who is in charge of Martin Marietta's space-station work, stands in a full-scale mock-up of one of the station's cupolas.*

Boeing and Martin Marietta have together spent nearly $100 million out of their own pockets preparing for it. Design engineers and accountants have worked on it at a fever pitch since April, and the companies involved are a reader's guide to the aerospace industry.

"It" is the competition for contracts to build the proposed U.S. space station, and November is shakeout time. That's when NASA is expected to award $8 billion worth of work that will represent a substantial commitment of time, money, and effort over the next decade.

The aerospace industry had already waited six months when NASA called for bids at the end of April. At that moment, the starting gun was fired. Contractors who had competed for preliminary design of the station scrambled to refine proposals for the next phase of the work, which will give the Western world its first permanent manned presence in orbit.

The $8-billion pie to be sliced in November has four segments, called work packages. Because the work for each package is extremely varied, companies have assembled teams to compete one-on-one for them. The result is the aerospace equivalent of the NFL playoffs.

"I don't think there's an aerospace company in the United States that's not on somebody's team," says Mark Hess, NASA's spokesperson for the space-station project.

The competition is hot. While none of the companies will fold up its tent if it doesn't receive a contract, the prime contractors have put a great deal of money and effort into preparing their bids, and they stand to gain or lose substantially in

# THE 29 COMPANIES POISED TO PROFIT FROM THE SPACE STATION

**Work on the space station is divided into four sections, each of which pits two lead contractors against each other for the contract. The chart below lists the lead contractors who will compete for each segment and the major subcontractors working with them.**

## SEGMENT I
### $2.5 Billion

| BOEING | VS. | MARTIN MARIETTA |
|---|---|---|
| *Grumman Aerospace* | | *General Electric, Astro Space Division* |
| *Lockheed Missiles and Space* | | *Hughes Aircraft* |
| *Teledyne Brown Engineering* | | *United Technologies (Hamilton Standard)* |
| *TRW* | | *USBI Booster Production* |
| | | *Wyle Laboratories* |
| | | *McDonnell Douglas Astronautics* |

## SEGMENT II
### $3.7 Billion

| ROCKWELL | VS. | McDONNELL DOUGLAS |
|---|---|---|
| *Grumman Aerospace* | | *Honeywell* |
| *Harris* | | *IBM* |
| *intermetrics* | | *Lockheed Missiles and Space* |
| *Sperry* | | *RCA* |
| *SRI International* | | |
| *TRW* | | |

## SEGMENT III
### $750 Million

| GENERAL ELECTRIC | VS. | RCA |
|---|---|---|
| *TRW* | | *Honeywell* |
| | | *IBM* |
| | | *Lockheed Missiles and Space* |
| | | *McDonnell Douglas* |
| | | *RCA* |
| | | *Computer Sciences* |

## SEGMENT IV
### $1 Billion

| ROCKETDYNE | VS. | TRW |
|---|---|---|
| *Ford Aerospace and Communications* | | *Lockheed Missiles and Space* |
| *Garrett Fluid Systems* | | *Planning Research Corp.* |
| *General Dynamics* | | *Analex* |
| *Lockheed Missiles and Space* | | *Teledyne Brown Engineering* |
| *Sundstrand* | | *Eagle Engineering* |

the intangibles of the space business.

The battle for the most expensive segment, estimated to cost $3.7 billion, pits Rockwell International against McDonnell Douglas. Both want to be chosen to build the station's structural framework. But perhaps the most hotly contested contract is for construction of the two pressurized modules where crew members will work and live. For that portion of the project, Boeing Aerospace is up against Martin Marietta for $2.5 billion worth of work.

Both sections are big and long-lasting, says Marc Vaucher of CSP Associates

# "I don't think there's an aerospace company in the United States that's not on somebody's team."

**—Mark Hess, NASA**

(Cambridge, Mass.). The two contracts mean long-term commitments to a highly visible program, and the companies that win them will get the advantages such public exposure will bring, he says.

The other two segments are much smaller. General Electric and RCA are competing for $750 million for an external free-flying polar platform and the observational research instruments it will carry. Either Rocketdyne or TRW will provide the station's power generation, management, and distribution system, estimated to cost $1 billion to build.

More minor contracts are further along the road to fulfillment. Boeing Computer Services (Seattle), for example, has won establishment of the station's Technical and Management Information System (TMIS), which it will begin in increments in December. NASA was scheduled to have awarded contracts for the software support environment and integration of the program's overall software as well as program support, including systems engineering and integration, by the end of the summer.

But the big money is elsewhere. "Boeing and Martin Marietta have put in more money and time than the others," says Wolfgang Demisch, an aerospace analyst at First Boston (New York City). Martin Marietta admits to spending at least $24 million of its own money pursuing the contract. Though the company is already prominent in the space-launch business, Demisch says, "if it gets a good chunk of the destination of the launchers, that would help as well."

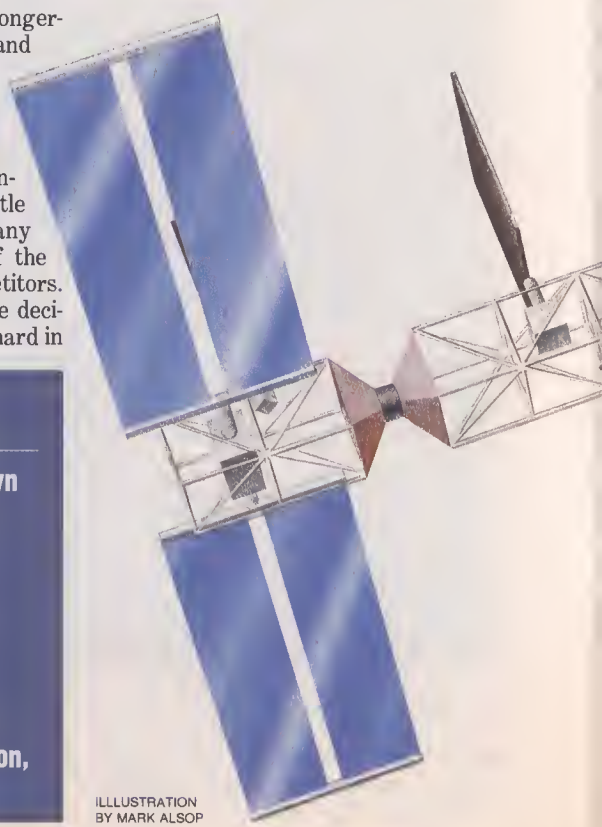
However, Boeing seems ready to put up whatever is necessary to win. A Boeing spokesperson said the company has spent at least $72 million out of its pocket. It has even built a new facility at Huntsville, Ala.—the site of the Marshall Space Flight Center, which will oversee work on that section.

Boeing and Martin Marietta have been among the more forceful companies in publicizing the case for the space station—and implicitly, each company's place in the program. In a series of newspaper advertisements launched last year and revived this past spring, Boeing asserted, "America needs the space station," and linked the program to longer-range goals, such as a mission to land on Mars. Martin Marietta has taken out magazine ads for the same purpose.

Boeing has reason to be especially aggressive in its pursuit of a contract. After losing the space-shuttle contract in the seventies, the company is anxious to wrest back part of the space program from its competitors. Boeing made an internal corporate decision about two years ago to push hard in civilian space projects as a diversification strategy, according to CSP's Vaucher. It wants to dilute its heavy military space commitments. The space-station competition, he says, "is a cornerstone of that strategy."

Both Boeing and Martin Marietta have taken an all-or-nothing approach in their bids. By contrast, several of the other lead contractors looking for a piece of the space station, such as McDonnell Douglas, have also submitted bids as subcontractors in other consortia. Part of the reason for the heavy competition may be the fact that, as Martin Marietta spokesperson Art Koski points out, whoever wins the contract to build the first modules would be well-positioned to build any that may be added later.

For several competitors—notably Martin Marietta, McDonnell Douglas, and Rockwell—the major intangible factor at stake with the space station is a continued highly visible presence in the civilian space business. All have been leaders in major space programs from *Apollo* through the shuttle. McDonnell Douglas, like Martin Marietta, has a solid slice of the booster business, with its Delta rockets. Martin Marietta has responsibility for the external tank and small subsystems of the space shuttle. And Rockwell is overseeing construction of the fourth

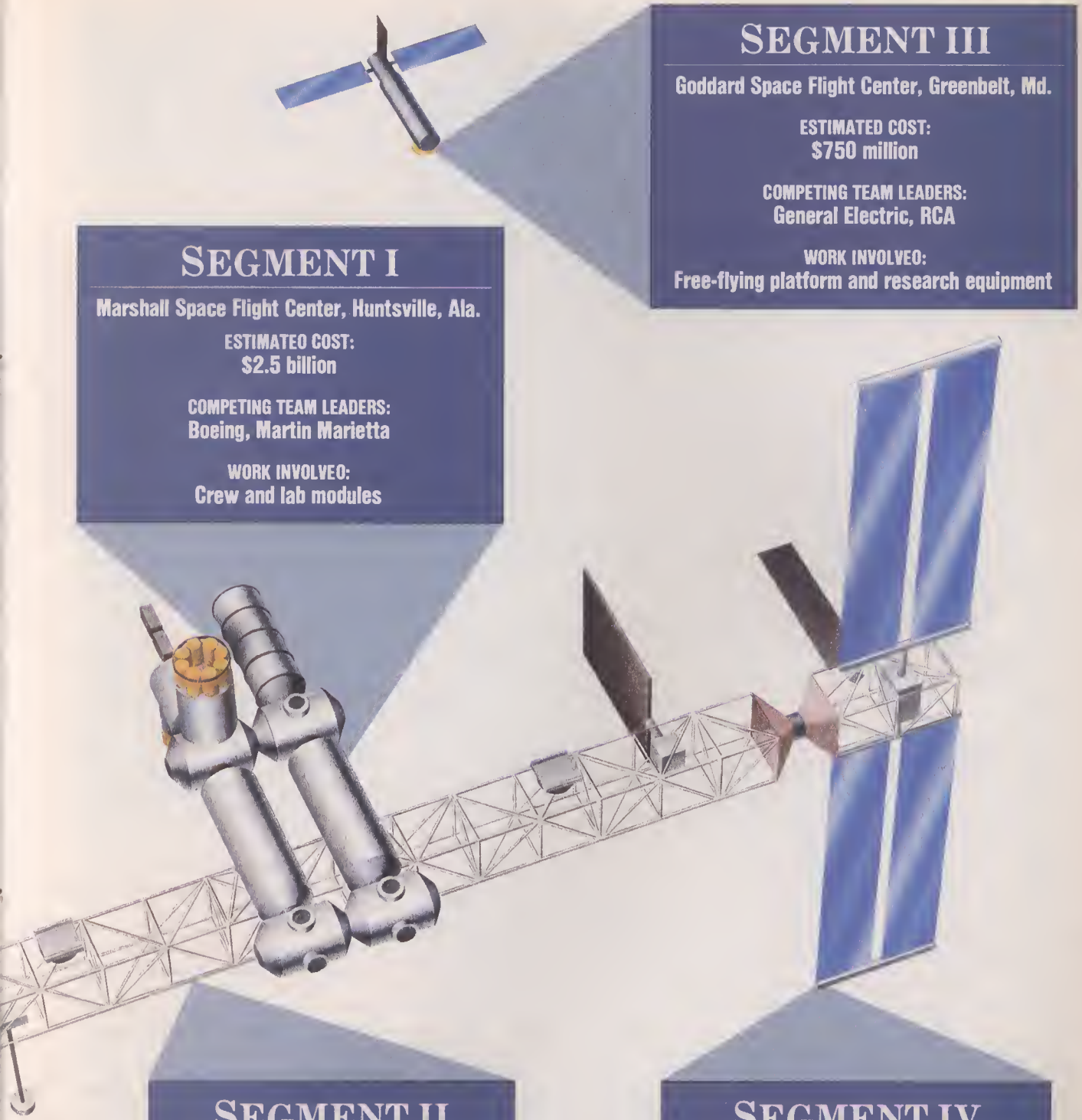


ILLLUSTRATION BY MARK ALSOP

## SPACE-STATION OBJECTIVES

**According to NASA deputy administrator Dale Myers, the scaled-down space station still fulfills four key objectives:**

- **Establishing a permanently manned presence in space.**
- **Developing a diverse set of capabilities for what is essentially a research center in space.**
- **Maintaining significant international participation in the project.**
- **Providing for improved capabilities through evolution of the station, if and when such capabilities are required and approved.**



## SEGMENT I

**Marshall Space Flight Center, Huntsville, Ala.**

ESTIMATED COST:
**$2.5 billion**

COMPETING TEAM LEADERS:
**Boeing, Martin Marietta**

WORK INVOLVED:
**Crew and lab modules**

## SEGMENT II

**Johnson Space Center, Houston, Tex.**

ESTIMATED COST:
**$3.7 billion**

COMPETING TEAM LEADERS:
**Rockwell, McDonnell Douglas**

WORK INVOLVED:
**Framework**

## SEGMENT III

**Goddard Space Flight Center, Greenbelt, Md.**

ESTIMATED COST:
**$750 million**

COMPETING TEAM LEADERS:
**General Electric, RCA**

WORK INVOLVED:
**Free-flying platform and research equipment**

## SEGMENT IV

**Lewis Research Center, Cleveland, Ohio**

ESTIMATED COST:
**$1 billion**

COMPETING TEAM LEADERS:
**Rocketdyne, TRW**

WORK INVOLVED:
**Power system**

# TIMETABLE FOR THE SPACE-STATION ASSEMBLY

**NASA estimates assembly of the space station via shuttle flights will begin in 1994. Shuttle flights will occur roughly every 90 days. The following is the estimated work to be done at each stage.**

**1998**

**Flight 19**
*Final outfitting of modules.*

**Flight 18**
*Four-member crew shift and provisions supplied.*

**Flight 17**
*Installation of remainder of Japanese experimental module.*

**Flight 16**
*Four-member crew shift and provisions supplied.*

**Flight 15**
*Installation of European Space Agency module.*

**Flight 14**
*Four-member crew shift and provisions supplied.*

**Flight 13**
*Installation of portion of Japanese experimental module. Additional four-member crew. Staffing is now complete.*

**1997**

**Flight 12**
*New crew shift and provisions supplied. Additional outfitting of modules.*

**Flight 11**
*Completion of power system. New crew shift.*

**Flight 10**
*First four crew members and provisions boarded. At this point the station is permanently manned.*

**Flight 9**
*Addition of two module connectors and cupolas. Module outfitting.*

**1996**

**Flight 8**
*Addition of living quarters for U.S. crew.*

**Flight 7**
*Equipping of module with lab equipment.*

**Flight 6**
*Addition of U.S. lab module.*

**Flight 5**
*Installation of polar platform.*

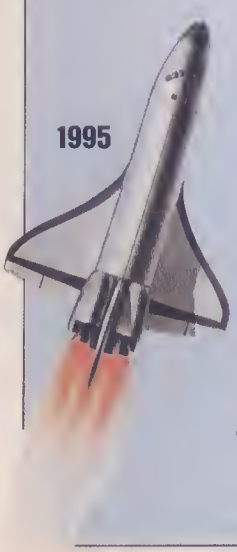
**1995**

**Flight 4**
*Installation of second air lock and remote manipulator arm.*

**Flight 3**
*Installation of thermal-control system, air lock, and mobile servicing center.*

**Flight 2**
*Same work as the first flight on opposite end.*

**Flight 1**
*Basic truss work and provision of 18.75 kilowatts of power to one end of project. One module connector installed.*



shuttle orbiter, to replace the ill-fated *Challenger*. Hence, a loss by any of those companies in the high-stakes competition for the space station would mean a halt to their involvement in cutting-edge space projects—and an end to using federal funds to create technological skills that can help a company obtain fresh contracts down the line.

However, many of the subcontractors have much less at stake. "I wouldn't be surprised if you see major primes or subs on losing teams incorporated into the winning teams," Vaucher says. Certainly if a losing prime contractor has proprietary processes to offer that interest NASA, the agency could well force a shotgun wedding that would ensure a broader distribution of space-station dollars.

The four-part division for detailed design and construction of the space station is similar to that used to award contracts for its preliminary design two years ago. Each part will be administered by a different NASA space center. In addition, some of the same teams who competed then are involved in the battle for detailed design and construction contracts. For example, both Boeing and Martin Marietta defeated General Dynamics for preliminary design of the modules. This time only one team will be chosen for each segment.

Some companies that served as prime contractors during the design phase are participating this time only as subcontractors. General Dynamics was a prime bidder for both module design and the structural framework. In the current phase, it appears only as a subcontractor for the power-system segment. Others who reduced their participation this time include Garrett Corp. and Lockheed.

The space station for which the bids are being sought differs considerably from that envisioned by NASA in 1984. It is smaller, less ambitious, and politically more controversial than the original. While no one doubts that the station offers plenty of commercial opportunities to the companies that win the contracts, the space industry's hopes that the station will promote a rapid development of commercial activity in space have dwindled considerably.

## HOW THE SPACE STATION WILL BE BUILT

The first phase of the space station is designed to provide a permanent manned presence in space by 1996. This modified space station is based on a 135-meter horizontal boom made from an advanced composite material. Four pressurized modules literally and figuratively form the centerpiece of the station. Two will be provided by the United States. In one, astronauts will perform experiments in microgravity and the life sciences; in the other, they will sleep, eat, and relax. If international negotiations are successful, the other two will hold laboratories from Japan and the European Space Agency.

At either end of the boom will be photovoltaic arrays that will generate 50 kilowatts of power, the station's primary source of electrical power. The system also includes a Flight Telerobotic Servicer for basic maintenance work on the station, and a free-flying platform in polar orbit to carry instruments for making earth, solar, and celestial observations. The station will provide permanent housing for eight astronauts.

NASA's timetable for the space station provides for 16 space-shuttle flights beginning in January 1994 to assume the first phase. Manned capability will follow one year later, and permanent operational capability by the fourth quarter of 1995.

"Men and women will be aboard the station base full-time, 24 hours a day, 365 days a year," explains Andrew J. Stofan, NASA's associate administrator for the space station. "This makes the space station different from what we have done in the past."

The first two shuttle flights will carry into orbit and then assemble the fundamental framework—the boom, the power system, and basic assembly tools. Payloads will start to go aloft during the third and fourth flights. After the polar platform is launched, orbiting and assembly of the U.S. laboratory module will begin, though in stripped-down form because it is so heavy. The module containing the astronauts' living quarters will follow, and by the end of the eleventh shuttle flight four astronauts will be able to occupy the station. At least 75 kilowatts of power on orbit must be available by the time the Japanese and European lab modules take to orbit next. Extra equipment and experimental setups will complete assembly and provide permanent living quarters for a crew of eight. At this point staffing will be complete. All flights after the sixteenth will resupply the station and carry on the work for which it is being built.

The value of the station's presence will be in experimental and observational science, of course, and also in orbital maintenance. "Things do break [in space], and they don't always work exactly right," Stofan says. "They need 'time in the shop.' The space station can be that shop. It could service many of the scientific instruments it carries as well as provide—in the future—for extended service of free-flying spacecraft that are within range of the station's manned base."

The space agency holds out the option of enhancing the capabilities of the so-called baseline station to enable its occupants to undertake such tasks as servicing satellites, processing materials, and carrying out more intricate scientifice experiments in orbit.

Contractors have been asked to submit two proposals: one to cover the initial configuration outlined above and later additions of enhanced capabilities and a second for construction of a fully enhanced station. That will give the agency a few years to decide whether to pursue the enlarged station and will not require any budgetary increase until 1991. In addition, some observers feel that debate over what the space station should be may delay the project even more.

There were several reasons behind NASA's turnabout. The *Challenger* disaster of January 1986 shocked the whole space industry. The destruction of one of the nation's four space shuttles drastically affected every program that depended, as the space station does, on extensive numbers of shuttle flights.

Growing costs also played a major role in the decision to cut back on the space station. The original plan envisioned a station that would be launched and manned by 1994 at a cost of about $8 billion. By April, when the new, bare-bones space station was unveiled, the cost of the original concept had soared to $13 billion, along with another $1.5 billion for engineering ground support. By contrast, the scaled-down version will require only the $8 billion initially proposed, and NASA has asked bidding contractors to present ideas for lowering the cost of their work packages.

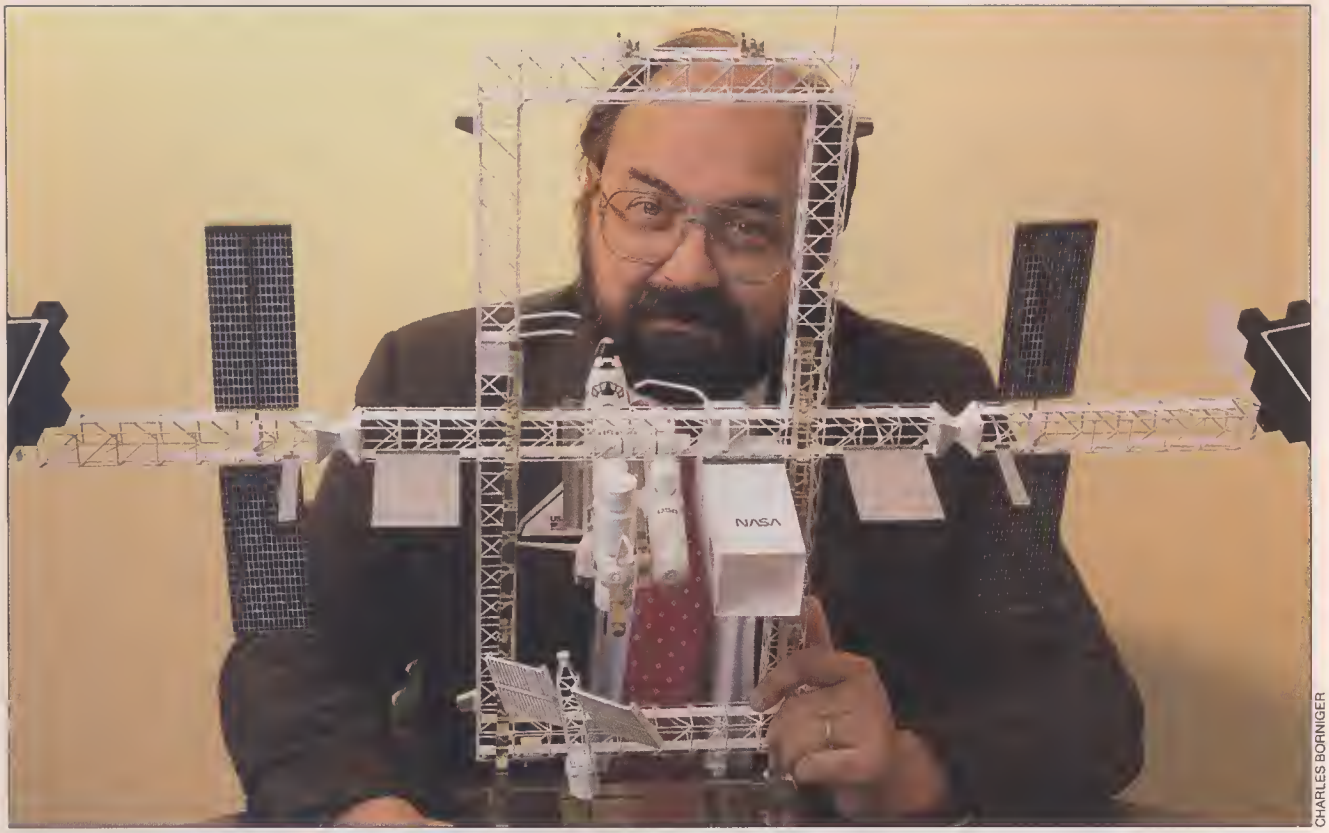
A less tangible factor in the lowered expectations has been the space agency's difficulty in defining the need for the space station. Hans Mark of the University of Texas, who was NASA's deputy administrator when the space agency sold the idea of the space station to President Ronald Reagan, recalls facing arguments from two sides: those who viewed the project as overly ambitious and those who regarded it as not ambitious enough. Both forms of opposition took on new life after the *Challenger* disaster.

**The companies that win contracts will get the advantages public exposure can bring.**

Critics in Congress and the scientific community have argued that the station as now planned falls somewhere between a quick and dirty orbital facility that would allow basic scientific experiments and a truly ambitious project that would act as a springboard for other missions such as a lunar base and a manned mission to Mars. NASA's solution to the crisis has been to split the design of the space station into two phases (see "How the Space Station Will Be Built").

However, the Boeing and Martin Marietta advertising that links the space station with a massive project, such as a mission to Mars, reflects a commonly held view that the space station itself cannot become the vehicle on which NASA's future will rest. Much like the shuttle, the space station is viewed as a means rather than an end—an edifice whose stated objectives are somewhat pedestrian to a generation brought up with a series of manned moon landings.

Some critics in the scientific communi-




CHARLES BORNIGER

*NASA deputy associate administrator Frank Martin holds a scale model of the space station.*

ty agree that the space station should form a stepping-stone to the planets—but argue that the station currently envisioned by NASA simply won't do that. In a report issued by the Planetary Society, an association that describes itself as "the largest space interest group in the world," astronomers Carl Sagan, Bruce Murray, and Louis Friedman argue that with the space station as planned, "we would learn little of the effects of long-duration spaceflight on humans—something our species will have to understand before setting out for Mars. Nor will it help us to assemble propulsion stages in orbit and build the ships that will take us to other worlds."

The report also excoriates the commercial justification for the station, whose rationale, it states, "rests largely on the vague notion that space holds great potential for manufacturing—of pharmaceuticals, alloys, ball bearings, and the like.... Outside the aerospace industry itself and, beyond verbiage, no large commercial concern advocates the space station strongly enough to share the costs of its development. No one has offered compelling arguments that space industrialization would be economically competitive with manufacturing on earth when a comparable capital investment is made. Nevertheless, the key and often-unstated assumption that products manufactured in space can be commercially profitable continues to permeate U.S. space-station planning."

Certainly, space commerce has achieved little beyond the communications satellite and earth-surveillance technologies that have their roots in the early years of the space age. Equally certainly, few companies have committed themselves to major investments in space manufacturing. However, with the race for space-station contracts now under way, it is possible that interest in space manufacturing will start to grow—if for no other reason than the fear of coming second to the Europeans, Japanese, or other overseas competitors. That competitive factor is already beginning to emerge; because one justification for the space station has been its anticipated financial benefits for industry, Congress and industry are pressuring officials to limit access to the station by potential competitors from other countries.

"At this point the whole space-station situation is fluid because of budgetary problems and the fact that Congress is dubious about it," First Boston's Demisch says. "The companies are doing a lot of technical grunt work, but it's not clear that we're one whit closer to a working space station."

NASA is becoming increasingly stringent about what it requires of contractors to prove their competence and commitment. As a result, the preparation for space-station bids has been proportionately some of the most detailed in the history of the space program. "The aerospace corporations are spending more and probably enjoying it less," Demisch says.

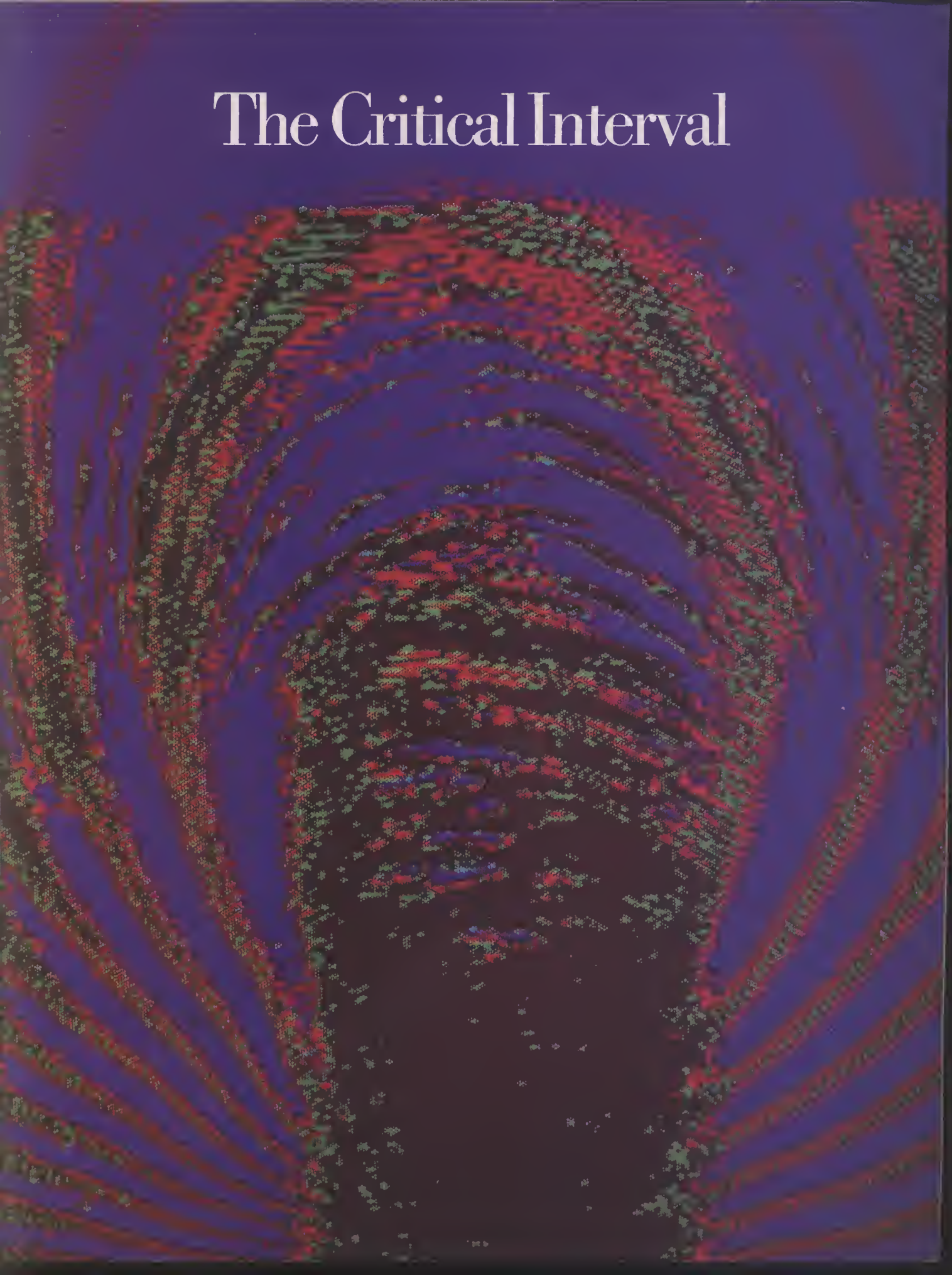
Now companies just have to wait to see if all that effort will pay off. □

## THE SPACE PROGRAM AT A GLANCE

| | | (1987 dollars) |
|---|---|---|
| ***Apollo* program** | *1962–1969* | **$26 billion** |
| ***Galileo* exploration vehicle** | *1965–1986* | **$ 1 billion** |
| ***Viking* mission to Mars** | *1968–1984* | **$ 3 billion** |
| **Hubble space telescope** | *1971–1986* | **$ 1.5 billion** |
| **Space shuttle** | *1972–1982* | **$30 billion** |
| **Space station** | *1984–present* | **$ 8 billion** |

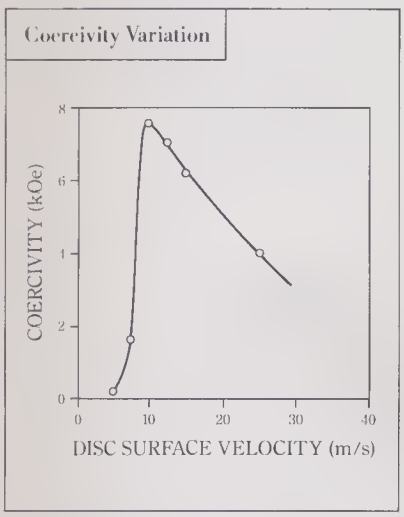
*Peter Gwynne is editor of* The Scientist, *a Washington, D.C.–based publication.*

# The Critical Interval



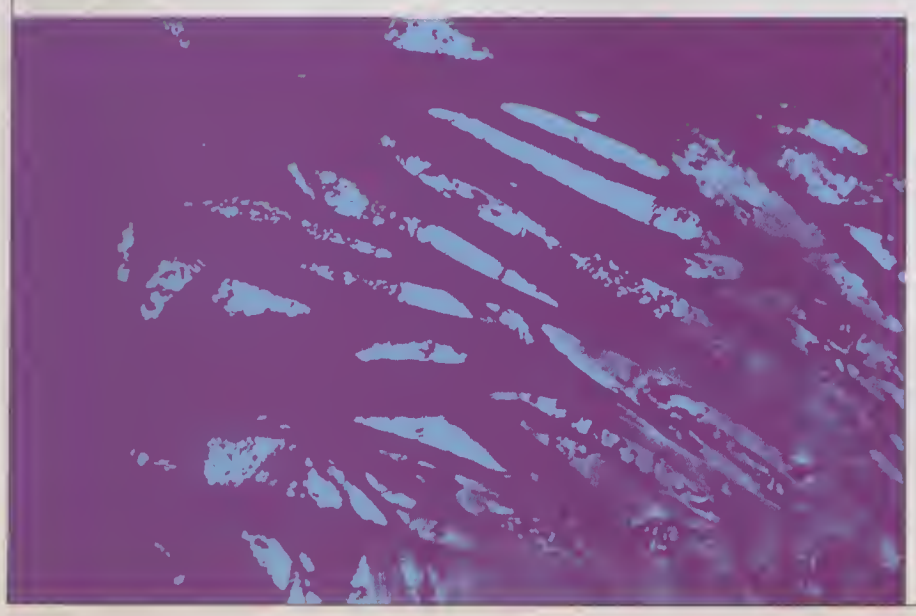
# The Critical Interval

*There has long been a need in the industrial world for low-cost, high-performance permanent magnets. Discoveries at the General Motors Research Laboratories have led the way toward meeting this challenge by the application of new preparation techniques to new rare-earth magnetic materials.*




*Coercivity of $Pr_{0.4}Fe_{0.6}$ plotted as a function of disc surface velocity.*

*Color-enhanced transmission electron micrograph of melt-spun $Nd_{0.4}Fe_{0.6}$ having 7.5 kOe coercivity.*



TWO properties characterize desirable permanent magnets: large coercivity (magnetic hardness or resistance to demagnetization) and high remanence (magnetic strength). Higher-performance magnets are required to reduce further the size and weight of a wide variety of electrical devices, including d.c. motors. Such magnets are available, but the cost of the materials necessary to produce them severely limits their use. The research challenge is to select, synthesize, and magnetically harden economically attractive materials of comparable quality.

Prominent among alternative materials candidates are alloys composed of iron and the abundant light rare earths (lanthanum, cerium, praseodymium, neodymium). Investigations conducted by Drs. John Croat and Jan Herbst at the General Motors Research Laboratories have led to the discovery of a method for magnetically hardening these alloys. By means of a rapid-quench technique, the researchers have achieved coercivities in Pr-Fe and Nd-Fe that are the largest ever reported for any rare earth-iron material.

Drs. Croat and Herbst selected praseodymium-iron and neodymium-iron based upon fundamental considerations which indicate that these alloys would exhibit properties conducive to permanent magnet development. These properties include ferro-magnetic alignment of the rare earth and iron magnetic moments, which would foster high remanence, and significant magnetic anisotropy, a crucial prerequisite for large coercivity.

That these materials do not form suitable crystalline compounds, an essential requirement for magnetic hardening by traditional methods, presents a major obstacle. Drs. Croat and Herbst hypothesized that a metastable phase having the necessary properties could be formed by cooling a molten alloy at a sufficiently rapid rate. They tested this idea by means of the melt-spinning technique, in which a molten alloy is directed onto a cold, rotating disc. The cooling rate, which can be varied by changing the surface velocity of the disc,

can easily approach 100,000°C per second. The alloy emerges in the form of a ribbon.

THE researchers found that variations of the cooling rate can dramatically affect the magnetic properties of the solidified alloys. In particular, appreciable coercivity is achieved within a narrow interval of quench rate.

Equally remarkable, synthesis and magnetic hardening, two steps in conventional processing, can be achieved simultaneously.

"X-ray analysis and electron microscopy of the high coercivity alloys reveal an unexpected mixed microstructure," states Dr. Croat. "We observe elongated amorphous regions interspersed with a crystalline rare earth-iron compound."

Understanding the relationship between the coercivity and the microstructure is essential. The two scientists are now studying the extent to which the coercivity is controlled by the shape and composition of the amorphous and crystalline structures.

"The development of significant coercivity is an important and encouraging step," says Dr. Herbst, "but practical application of these materials requires improvement of the remanence. Greater knowledge of the physics governing both properties is the key to meeting the commercial need for permanent magnets."

## TECHNOLOGY UPDATE: 1987

Subsequent to the research reported above, Drs. Croat and Herbst added boron to neodymium-iron as a glassifier to increase the formation of the elongated amorphous regions they had observed in the material. They reasoned that shape anisotropy, and thus coercivity, was related to the presence of these amorphous micro-needles.

They discovered that the addition of boron promoted the formation of a previously unknown ternary compound: $Nd_2Fe_{14}B$. Its atomic magnetic moments are arranged so that this compound has a large magnetization. At the same time, the researchers found that, compared with neodymium-iron, coercivity had risen from 8 to 20 kOe, and that the magnetic energy product had increased by a factor of seven.

On March 31, 1987, General Motors dedicated a new Delco Remy plant in Anderson, Indiana for the production of magnetic material and finished magnets made from $Nd_2Fe_{14}B$ under the commercial name MAGNEQUENCH.

**General Motors**

GM

MARK OF EXCELLENCE

## THE MEN BEHIND THE WORK

Dr. John Croat and Dr. Jan Herbst did their original work on rare-earth magnetic materials when both were Staff Research Scientists in the Physics Department at the General Motors Research Laboratories.

Dr. Croat (right) holds a Ph.D. in metallurgy from Iowa State University. In 1984, he joined GM's Delco Remy Division to stabilize the melt-spinning process for the commercial production of MAGNEQUENCH materials. He is currently Chief Engineer at the Indiana plant.

Dr. Herbst received his Ph.D. in Physics from Cornell University. He is now a Senior Staff Research Scientist and Manager of the Magnetic Materials Section in the Physics Department of the GM Research Laboratories. His research interests also include photo-emission theory, the physics of fluctuating valence compounds, and superconductivity.

Dr. Croat joined General Motors in 1972; Dr. Herbst in 1977.

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# New Filters Clean Up In New Markets

A.J. BERNSTEIN

■ *Corning's John Howitt, technical manager of advanced ceramics, holds a diesel-engine filter–a product promising a big payoff as a result of the push to reduce soot emissions.*

## LOWER COST AND HIGHER PERFORMANCE BRING NEW OPPORTUNITIES FOR MEMBRANE FILTERS

After being developed for several decades and languishing in relative obscurity in niche markets, membrane filtration systems are at last gaining widespread industry acceptance for purification and separation tasks. Spurred by environmental pressures and attracted by membranes' lower usage costs and improved performance, industries such as waste treatment, chemical processing, refining, food processing, and biotechnology are expected to drive the market for membrane filtration systems to $2 billion by 1995, compared with sales of about $500 million last year.

Membrane filters remove sub-micron-sized elements that are suspended and dissolved in a liquid or gas, which is a much finer separation than conventional mechanical filters can perform. The name *membrane* derives from early experiments in ultrafine filtration that used organic membranes, such as stomach linings from livestock. Systems may cost anywhere from several million dollars for a heavy industrial application to about $10,000 for maple-syrup processing for small farms. The three standard membrane processes—microfiltration, ultrafiltration, and reverse osmosis—use either hydraulic or gaseous pressure to drive a substance through the filter. If a gas is being filtered, it dissolves into the membrane on the high-pressure side and diffuses through to the low-pressure side. There the gas is desorbed, leaving behind the filtered elements. Membranes for separating liquids have tiny pores that exclude particles as the solution permeates through the filter.

Microfiltration removes small suspended particles and large dissolved molecules ranging from 0.1 micron to about 10 microns, including particles such as yeast and molds. Ultrafiltration retains macromolecules—particles larger than 0.001 micron, such as bacteria and proteins—allowing smaller molecules, such as water and sugar, to pass through. Reverse osmosis, also known as hy-

BY PAUL HURLY

perfiltration, removes dissolved elements, leaving only the liquid base itself. This process was first used in seawater desalination. Today it is gaining wide use for gas separation and processing liquid wastes.

A number of factors account for the growing preference for membrane filters over older separation technologies, such as distillation. For one, membrane systems have become more productive and economical to operate, especially with the emergence of reverse-osmosis systems and the development of thin, asymmetical membranes consisting of two or more bonded layers of differing densities. For example, industry studies show that reverse-osmosis membranes consume about 200 times *less* energy than a conventional evaporator used for making fruit-juice concentrate. What's more, with membranes, food products can often be concentrated at ambient temperatures without using heat, which destroys flavor and nutrients and darkens color. This advantage also makes membranes the technology of choice for separating heat-sensitive compounds in biotechnology and pharmaceutical products.

Membrane systems are generally more compact than the equipment they replace, making retrofitting easy and economical. The modular design of most membrane equipment simplifies expansion if more capacity is needed.

Further, membranes are able to handle more kinds of industrial applications due to recent advances in their design, materials, and production, especially with the newly introduced ceramic and bipolar membranes. Other refinements—like filter-system development and electrofiltration—continue to improve their performance. The most promising new membrane applications include industrial gas separation, the treatment of liquid waste, food and beverage processing, groundwater treatment, and the desulfurization of waste gases produced during combustion.

**CERAMIC COMES OF AGE.** Ceramic membranes have been available for more than a decade, but until recently they were plagued by inconsistent quality. Better manufacturing methods now produce ceramic membranes with uniform pore sizes. Due to the resulting improvement in mechanical and thermal properties, ceramic-membrane filters now generally outperform polymer membranes, their more established competitor.

As a result, the market for ceramic membranes, presently about $200 million per year, is expected to grow by 30 percent annually into the nineties, according to industry sources. Much of this growth will occur as ceramic membranes supplant other membrane materials, such as polymers, for many applications in food processing, biotechnology, and pharmaceutics.

Ceramic membranes are made by blending dry mineral powders, such as alumina, spinel, cordierite, and zirconia, in various proportions with a solvent to form either a slurry, which is poured into a mold, or a dough, which is extruded. The resulting configurations, either hollow fibers, flat plates, or honeycombs, are then dried and fused together. Layers of supporting material are added to complete the filter.

Companies that currently supply ceramic membranes include Norton (Worcester, Mass.), Corning Glass Works (Corning, N.Y.), Ceraver (Tarbes, France), Societe de Fabrication d'Elements Catalytique (SFEC, Bollene, France; marketed in the United States by L & A Engineering and Equipment, Turlork, Cal.), and NGK Insulators (Nagoya, Japan). Also, DuPont (Wilmington, Del.), Alcoa (Pittsburg, Pa.), and Osmonics's Hytrex Filter Division (Minnetonka, Minn.) plan to introduce ceramic-membrane products within the next two years.

One of the conventional types of membranes is the asymmetric polymer membrane, which consists of a filtering layer bonded to a microporous support layer. The thin wall and variable pore size of asymmetric membranes give them a faster permeation rate compared to homogeneous membranes, ones with a single layer. Cellulose acetate was the first polymer used to manufacture asymmetric membranes and is still widely used. Other materials, such as polyamides, polysulfone, polyvinylidene flouride, and polytetrafluorethylene have expanded the uses of polymer-membrane processes because of their lower cost, improved performance, wider pH and heat tolerance, and improved maintenance.

Thin-film composite membranes—another established design—are similar to asymmetric membranes in that they have a thin, dense polymer skin bonded to a microporous support film. But thin-film composite membranes are produced in two steps, whereas asymmetric membranes are produced in one. Monsanto (St. Louis), UOP (Des Plains, Ill.), and General Electric Medical Systems Division (Milwaukee) manufacture thin-film composite polymer membranes.

**OUT WITH THE OLD.** Ceramic membranes outperform both asymmetric-polymer and thin-film composite membranes in several ways. First, ceramics withstand temperatures as high as 1000° C., enabling them to, say, separate oxides and other impurities from molten aluminum and magnesium, says Boyd Sorenson, a DuPont technical-ceramic manager. Polymeric membranes degrade at 100° C.

Because ceramic membranes tolerate sodium hydroxide, dichromic acid, and other sanitizers, they can be more thoroughly cleaned than other designs—an important factor for many applications, such as food and pharmaceutical processing. Thin-film composites break down when exposed to chlorine sanitizers commonly used in the food industry. What's more, ceramic membranes can be cleaned with steam up to 140° C., whereas polymeric memanes cannot be steam-cleaned. Steam cleaning sterilizes more completely than

## Membrane Business Opportunities

| Process | Top Applications | 1986 Sales | 1996 Sales Forecast |
|---|---|---|---|
| **Microfiltration** | Biotechnology<br>Chemical<br>Electronics<br>Environmental Control<br>Food & Beverage<br>Pharmaceutical | $550 million | $1.5 billion |
| **Reverse Osmosis** | Desalinating Seawater<br>Electronics<br>Food & Beverage | $120 million | $530 million |
| **Ultrafiltration** | Biotechnology<br>Chemical<br>Environmental Control<br>Food & Beverage | $350 million | $1.1 billion |
| **Gas Separation** | Environmental Control | $20 million | $1.5 billion |
| **Total** | | **$1 billion** | **$4.6 billion** |

SOURCE: CORNING

PETER VIDOR

*Allied-Signal's Joseph G. Schon eyes the growing market for his Aquatech membrane filter.*

chemical methods, explains Jacques Gillot, technical director of Ceraver. Ceramic membranes can also be heated to 500° C. to burn out impurities trapped during molten-metal filtration—the only possible way to remove such residue, DuPont's Sorenson says.

A major drawback of ceramic membranes is their brittleness. Because of this, they have been limited largely to high-temperature or corrosive materials deemed too tough for polymer membranes. But reliability is expected to increase as production methods improve. Already some manufacturers rate ceramic filters for pressure up to 150 pounds per square inch, making them suitable for most microfiltration and ultrafiltration applications.

Cost can be another deterrent to using ceramic membranes. Generally they are three to six times more expensive than polymer membranes and one-and-a-half times more expensive than conventional stainless-steel filters. However, ceramic manufacturers argue that their filters have double the life of polymers. Furthermore, because ceramics also perform as much as 5–10 times better than polymer and metal filters, a smaller ceramic membrane can often do the job of a larger polymer unit, says Norton's Eric Lillo, director of the Ceraflo product line.

Among the most promising ceramic-membrane products is Celcor, a cordierite-membrane filter for diesel-emission control from Corning. It is currently used on Mercedes-Benz cars sold in California. The diesel-engine market for emission-control devices will reach several hundred million dollars by the mid-nineties, according to Marshall Burke, marketing manager for the Diesel Filtration Division.

**As markets grow, companies are devoting more resources to membrane-system design.**

Corning also makes a zirconia-spinel ceramic filter for the separation of titanium and hafnium impurities from superalloys used in aircraft engines. A cordierite-mullite Celtex filter sold by Corning removes slag from molten iron, in addition to oxides from molten magnesium and aluminum.

Both Norton and France's SFEC have sold most of their ultrafiltration ceramic-membrane systems to food processors. Norton supplies Ocean Spray Cranberries (Plymouth, Mass.). More than half of SFEC's 100 systems installed worldwide are used to process milk and eggs, purify and clarify vinegar and fruit juices, and separate the components of whey.

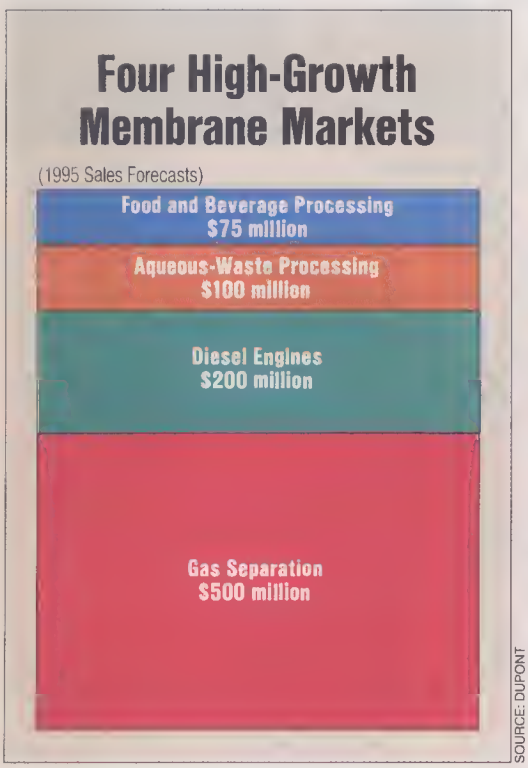
NGK Insulators produces a ceramic membrane for cold sterilizing bacteria from beer and a larger-pored membrane filter for gas and liquid filtration. It also manufactures a cordierite membrane catalyst for automotive-emission control.

**BOOSTING BIPOLAR.** Bipolar membranes are a second new filter technology gaining wider acceptance. A current market leader, Allied-Signal (Mount Bethel, N.J.) sells its Aquatech bipolar line to industrial processors that recover, recycle, or dispose of aqueous salt streams. For instance, a $2-million system under construction will recycle used pickle liquor from a Washington Steel plant (Washington, Pa.). At Ontario Hydro's Lakeview Generating Station (Toronto), Allied-Signal recently completed job-site trials of its Soxal bipolar-membrane system for desulfurizing industrial flue gas. Another trial is under way at the Electrical Power Research In-

stitute (EPRI) High Sulfur Test Center (Lockport, N.Y.).

Bipolar membranes rely on electrodialysis—the separation of molecules using electricity. They are typically used in a chamber divided by membranes, and they separate out a pure acid and the corresponding base (two chemical substances that would readily combine, forming covalent bonds). The membrane itself consists of a thin layer of water sandwiched between two filtering membranes. One membrane is a cation—it will only permit positively charged ions to pass through; the other is an anion membrane—permeable only to negatively charged ions. When direct current is applied, the water dissociates into hydrogen and hydroxyl ions, which move through the appropriate membranes and into the chamber's outer compartments. Here the ions are exposed to the salt solution. Hydroxyl ions react with the salt to form a base, while hydrogen ions produce an acid. Both may then be removed and discarded or recycled.

A 1986 study by EPRI and the Department of Energy showed the aqueous process was potentially the lowest-cost method for removing sulfur from industrial smoke emissions, according to Joseph G. Schon, general manager of Allied-Signal's Aquatech System. Since the study was based on the 1982 sulfur price, which has since doubled, Schon argues that the process is even more cost-effective. The technology is not only a promising remedy to sulfur-based air pollution; as the world's production of sulfur declines, sulfur separated from flue gas will provide more than half of the world's supply by the next century, some studies show. Schon expects these factors to give a major boost to bipolar-membrane technology during the next decade.




Electrofiltration, a membrane-filtration enhancement, is currently undergoing extensive research and development. So far it shows potential in improving microfiltration systems' flow rates. Trials are now being conducted in Britain on large-scale industrial processes.

In a normal separation process, a cake of retained particles forms across the surface of the membrane as a liquid and its solutes move toward the membrane. As the cake grows, resistance to flow increases. In electrofiltration, a current applied across the surface of the membrane forces away the filtered ions, thereby improving the filtration flow rate.

**A SYSTEM APPROACH.** In order to respond to the new market opportunities for membrane systems and to ensure technological improvements are applied effectively, companies are paying much greater attention to total membrane-system design. DuPont, for example, has integrated its engineering resources from five separate fields. Meanwhile, other companies, such as Corning, are contemplating acquisitions to bolster their expertise, while others have already done so. W. R. Grace acquired Amicon, a manufacturer of ultrafiltration membranes for biotechnology separations, and in 1985 Monsanto purchased the Kemp Co. Competition from Europe and Japan is also increasing, forcing U.S. companies to improve their marketing operations.

Several promising new markets are opening for industrial membrane technology. For one, sales of membrane systems for gas separation are expected to increase from $25 million in 1985 to $500 million by 1995, according to DuPont market forecasts. The recovery and recycling of hydrogen alone is expected to total about $200 million by 1995. DuPont, Dow, Monsanto, W. R. Grace, Separex, Ube, and Delta Engineering have developed separation systems for high-purity hydrogen recovery.

The removal of carbon dioxide from natural gas could be worth more than $150 million per year, according to some projections. DuPont, Dow, Monsanto, and W. R. Grace have all tested membrane-separation systems that recover carbon dioxide for reuse in secondary oil recovery. However, the current depression of the oil market is slowing development of these systems.

Flue-gas desulfurization has yet to become a significant market in this country, but U.S. companies are pursuing foreign markets in Canada and Europe, where pollution legislation is more stringent. Bend Research (Bend, Ore.), for example, developed a scrubber that removes up to 90 percent of the sulfur dioxide from flue gas.

Another emerging market, the processing of aqueous-waste streams, though still in its infancy, could reach nearly $100 million in sales by 1995, DuPont estimates. Cultivating this market will be one part of solving the growing problem of hazardous-waste disposal. It is estimated that approximately 150 million tons of hazardous waste is disposed on-site each year. This volume is expected to increase by 10 percent annually.

Many systems are essentially waiting for the waste-treatment market to develop. However, DuPont has already used its Permasep reverse-osmosis system to concentrate textile waste at its Seafood, Tex., nylon plant. A major apple-juice producer in Ontario simultaneously uses Patterson-Candy ultrafiltration and reverse-osmosis units to clarify its product and to clean up its sewage discharge in compliance with government regulations. Studies have shown that ultrafiltration can save a fruit-juice operator up to $800 a day in labor, materials, and waste-disposal costs. Membrane Technology and Research (Menlo Park, Cal.) has developed a silicone rubber, neoprene, and hypalon membrane to concentrate organic solvent vapors such as octane, toluene, trichloroethylene, and acetone in industrial waste streams.

Membrane systems can also be used to treat groundwater contaminated by hazardous wastes. Concentrating the waste prior to treatment can significantly reduce treatment costs.

Finally, membrane processing of food and beverage products is expected to increase from its current level of $10 million to about $75 million by 1995. Applications are ongoing in many sectors and include cold sterilization, purification, and concentration.

These promising new markets, coupled with applications in pharmaceuticals and biotechnology, are expected to greatly increase the installed base of membrane systems and fuel the push for even more productive, efficient membrane materials and systems. □

*Paul Hurly is a free-lance writer based in Burlington, Ont.*

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# Phone Companies Argue Over New Standards

***ISDN will link voice, data, text, and video communications—if phone companies can agree on what it should be***

BY DWIGHT B. DAVIS

The telecommunications providers of the world have a common vision of the future, and they call it ISDN. Under ISDN—which stands for integrated services digital network—voice, data, text, and video information would share high-speed digital transmission facilities. All types and makes of equipment on the network could exchange information worldwide. Users would pay less for current network services and would have access to a panoply of powerful new services. What's more, these advanced services would be available on existing network lines, without needing expensive rewiring.

But before this vision can be realized, questions about the nature, cost, and implementation schedule of ISDN capabilities must first be answered. Until businesses—especially those in the United States—know how the public carrier networks will evolve, they will be unable to confidently upgrade their own communication facilities.

The ISDN outlook is particularly murky in the United States because of the fragmentation of this country's telecommunications industry. Since the AT&T breakup, divisions have cropped up among local and long-distance phone companies, among regional phone companies, and among equipment vendors of all stripes. Each of these parties wants a say in how ISDN is configured. Some even view ISDN as a threat to their services or products and are hoping for its failure. "Divestiture couldn't have come at a worse time from a standards perspective," says Warren G. Bender, deputy manager of the telecommunications section at consultant Arthur D. Little (Cambridge, Mass.). "In 1983 people didn't understand the potential of ISDN."

In Europe and Japan, by contrast, the telecommunications networks are still controlled by monopolies, which can more easily implement ISDN capabilities nationwide. Some observers go so far as to say that such monopolies are essential to ISDN's success. "ISDN can be implemented without difficulties only in countries with one uncontested network provider," claims Helmut Schon, director of telecommunications at West Germany's Federal Ministry of Posts and Telecommunications. Speaking at the International Switching Symposium in Phoenix last March, Schon said, "The more that independent providers share in the provision of a country's telecommunications network, the more that the innovative capacity of that country's telecommunications system as a whole will be impaired."

ISDN backers in the United States take issue with this grim assessment. "The fragmentation of the U.S. market certainly doesn't help the implementation of ISDN," admits Joe Miller, director of ISDN technical development at US West (Denver), one of the seven regional Bell operating companies (RBOCs). "But I think we're easily abreast of Europe and Japan and starting to pull ahead." The RBOCs oversee the 22 divested Bell operating companies (BOCs), which provide local phone services. Miller and other ISDN proponents say commercial ISDN offerings will begin to appear next year and will become widely available in 1989–90.

Even if countries with telecommunications monopolies *do* have an initial advantage, they may suffer in the long run from lack of competition, says John Holmblad, vice-president of Network Systems at Telenet (Reston, Va.), a provider of public and private data networks and a subsidiary of long-distance carrier US Sprint. Because market forces—not monopoly fiat—will shape the implementation of ISDN in the United States, the end result will be more innovative and will better suit customers' needs, he believes.

**SHIFT TO DIGITAL.** The push toward ISDN standards is occurring as the public phone networks move to upgrade their network facilities to support digital, rather than analog, transmissions. "Almost every piece of new equipment going into the network today is digital," says Alan A. Gonsalves, a senior product planner at AT&T Network Systems (Basking Ridge, N.J.).

Once network digitization is in place, data and text from computers will no longer have to pass through a modem to be converted to analog waves. Rather, voice and video transmissions, which are analog by nature, will be converted to digital pulses before entering the network and reconverted to analog signals at their destination. Digital transmissions are more reliable than analog, a critical advantage for ensuring data accuracy. In addition, digital signals from


PETER VIDOR

AT&T NETWORK SYSTEMS

**"Vendors will unite on ISDN's basic standards, but compatibility problems may arise within the higher-level ancillary features."**

Jack McDonough
ISDN Terminal Product Manager

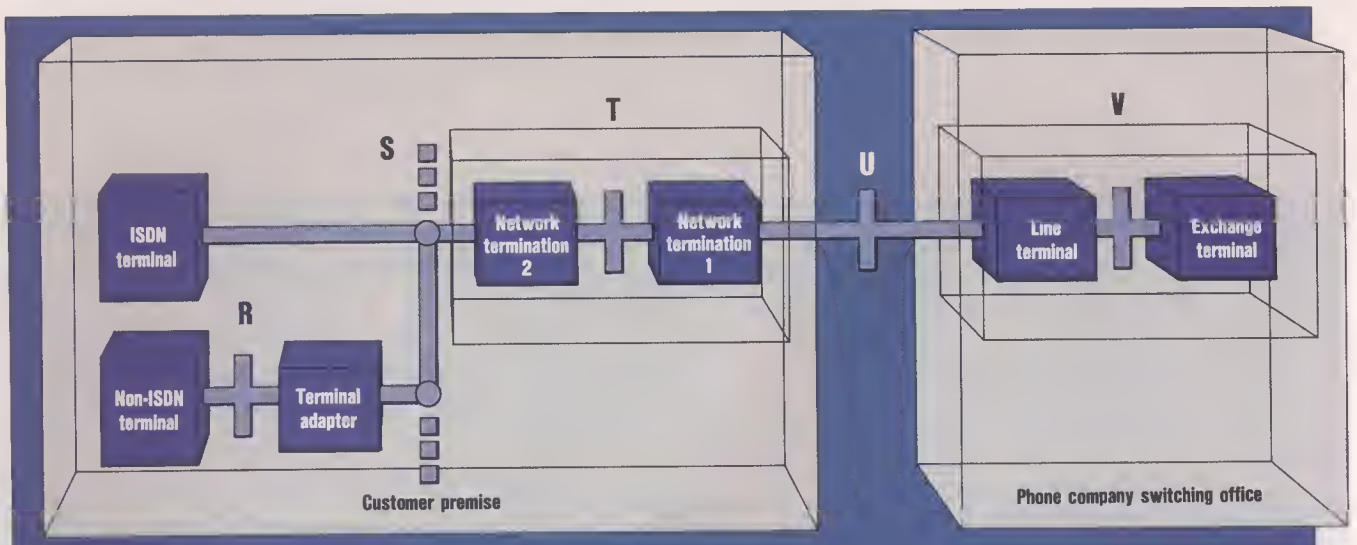
different sources can be mixed to use the phone line's full capacity and then be separated for final delivery.

For all its advantages, however, network digitization has one big pitfall: lack of standardization. Different countries' analog phone networks evolved independently. In the United States, AT&T established its own equipment and transmission standards, which differ considerably from those implemented in European and other countries. This disparity has caused relatively minor problems as the different countries' networks have interconnected voice transmissions. But the problems have grown considerably more complex as networks begin to carry and exchange data as well.

By establishing worldwide ISDN standards before reaching full digital capacity, countries hope to reduce their networks' incompatibilities. Because ISDN is intended to build on each country's existing network, however, some intercountry differences will remain. For example, the high-speed ISDN primary rate will be approximately 1.5 megabits per second (Mbps) in the United States, reflecting its existing T1 digital communications rate. In Europe the primary rate will be 2.048 Mbps. But these differences will fall within the range of ISDN standards and will be far fewer than current incompatibilities.

**ISDN'S PROMISE.** Should networks successfully incorporate the ISDN digital standards, users stand to gain a wide range of benefits. The first services will be targeted at large businesses, but they should eventually reach residential customers. Most industry observers believe that one of the first effects of ISDN availability will be lower rates for current services. "We recognize fully well that we will have to offer users some economic incentives with ISDN, or they won't buy it over existing services," says US West's Miller.

At the most basic level, ISDN should provide users with a common wall-plug interface to connect many types of equipment, from telephones to computers to facsimile machines. In addition, ISDN users may get many voice features through the network that are now only offered locally by on-site private branch exchanges (PBXs). For example, users could set up conference calls among different cities. Or if a dialed number is busy, the caller could "camp" on the busy line via the




## The Standard Interfaces—R, S, T, U and V

*ISDN consists of several interface points, each a site for potential products. On the user's premises, phone terminals such as PBXs hook up to the network via an S interface. Terminals that are not ISDN-compatible need an adapter, to which they connect via an R interface. A standard U interface, which links user equipment to the switching office, has not been firmly established. In the meantime, switch manufacturers are using proprietary interfaces that will work only with terminals designed specifically for them. Finally, the V interface links equipment within the switching office.*

MARK ALSOP

ISDN network, which will ring the distant phone as soon as it is hung up.

Most exciting to businesses, however, is the prospect of a public network providing fast transmission of data as well as voice. To get this today, companies must either lease dedicated digital lines from phone companies, use private data networks, or set up their own communications facilities. With ISDN, applications such as computer communications, Group IV (high-speed) facsimile transmissions, and videotex could easily be handled over the public network.

Beyond these familiar applications are a host of potential capabilities not yet possible on any network. Because it will carry signaling information on a separate channel—rather than on the same channels that carry the actual network traffic—ISDN should be able to combine voice and data applications in innovative ways. When a phone rings, for example, the network could identify the caller on a computer screen even before the phone is answered. The computer, in turn, could automatically retrieve a file on the caller. Once on the phone, the speakers could use the same ISDN connection to call up identical information on their computer screens or to transmit data back and forth.

Such services are viewed as a major strategic weapon by the public carriers, according to Doane Perry, senior telecommunications consultant within International Data's Communications Research Group (Framingham, Mass.). The Centrex phone-switching capability provided by local phone companies has had trouble keeping pace with the features offered by customers' own PBX systems, he notes. Meanwhile, phone companies' attempts to sell PBXs and similar equipment themselves have been only partly successful. With ISDN, Perry says, phone companies can "make people use the network."

The technology to implement ISDN is available. Computer vendors have been installing proprietary data networks with similar capabilities for years. The success of ISDN, therefore, depends on how much customers are willing to pay for the new services, says Neil Wellenstein, market development manager at Motorola (Phoenix).

**COMPATIBLE PRODUCTS.** Before any services can be provided, phone-company and customer equipment must be modified or replaced with products that comply with ISDN standards. Products touted as ISDN-compatible are already on the market from companies such as AT&T and Northern Telecom (Research Triangle Park, N.C.). This claim is often misleading, however; rarely does one vendor's system work with another's.

One reason for this lack of compatibility is that ISDN standards are not yet complete. Standards for some interfaces—notably those that connect communications equipment on the customer's premises to the network—are relatively firm. But there's still no agreed-on way to connect equipment to the switches at the phone company's central office. Each vendor of central-office switches, therefore, has its own proprietary version of what they all call a U interface.

The good news is that the American National Standards Institute (Washington, D.C.) will likely set the missing standards by year end. "Switch manufacturers will probably incorporate the U-interface in their products in 1989 or 1990," says Wayne Felts, manager for ISDN implementation at Bell Communications Research (Bellcore) in Livingston, N.J., the R&D facility of the divested phone companies. Once this is done, he says, any ISDN terminal equipment should be able to access any central-office switch.

Many equipment vendors believe they can't afford to wait for standards to filter down. Local phone companies, hoping to dampen the market's appetite for private communications networks, are pushing hard for rapid ISDN implementation. Thus, AT&T, Northern Telecom, Siemens (Boca Raton, Fla.), Ericsson (Garden Grove, Cal.), GTE (Stamford, Conn.), and other switch vendors are seizing the opportunity to sell expensive, ISDN-compatible equipment to central offices. This competitive activity, in turn, is stimulating the market for customer-premises equipment.

Semiconductor manufacturers, too, are poised to profit from ISDN. Most have formed alliances, attempting to combine their chip-making expertise and economies of scale with the systems-level experience of ISDN switch vendors. Chip mak-

CHUCK EGERTON

NORTHERN TELECOM

**"To be successful, ISDN must be able to exchange information with existing data networks, such as those running under IBM's Systems Network Architecture."**

Barry J. Eckhart
Director,
ISDN & Planning

er Intel, for example, has entered a development pact with AT&T, Motorola with Northern Telecom, National Semiconductor with Thomson, and Siemens with Phillips. Both Advanced Micro Devices and Texas Instruments, meanwhile, are reportedly maneuvering to form an ISDN relationship with switch maker Ericsson.

Producing ISDN chips prior to the ratification of full standards can be risky business for the semiconductor vendors, however. Some early entrants, such as Siemens Components, have already been forced to redesign their ISDN circuits as standards are firmed up. Similarly, terminal and switching equipment using the early chips may also have to be modified. "There's always an evolution," Motorola's Wellenstein admits, "but the standards are close enough now that we can build first-generation products that will have a reasonable market life."

Semiconductor vendors are entering the ISDN market now even though the market will be small for some time. "We don't anticipate volume to begin picking up until 1989, with payback not really starting until 1990 and beyond," Wellenstein says. But if ISDN lives up to its potential, the market for products should be enormous in the nineties, he says. "To be a major player, we have to be involved now."

Already on the market are products with built-in ISDN interfaces as well as adapters that link non-ISDN products to the network. AT&T Network Systems, for example, offers a line of ISDN terminals for voice and data transmission (all models work only with AT&T's 5ESS digital switch). In the adapter market, Hayes Microcomputer Products recently introduced a circuit card that plugs into IBM PCs and compatible computers. One version of the card interfaces to 5ESS switches, another to Northern Telecom's DMS-100 switches. Hayes and other modem companies face the prospect of their market evaporating as the networks shift from analog to digital transmission. ISDN interface cards are one way to buttress their business.

**ISDN TRIALS.** To test all this equipment and investigate possible ISDN services, the phone companies have instituted a series of trials around the country. Each tests a few selected capabilities as well as network switching and customer-premises equipment. Much of this activity is being coordinated by Bellcore, which is also testing equipment to ensure that it meets interface standards. Bellcore is documenting the trials and will make the results available to all of the regions—"so they won't have to learn all of the lessons themselves," Felts explains.

One well-publicized trial, run by Illinois Bell in cooperation with fast-food giant McDonald's, is testing voice, data, imaging, and messaging services. McDonald's initiated this project when it approached Illinois Bell to find ways to upgrade the company's internal communications. Most trials, though, are the phone company's idea. Their value is thus limited, some industry observers say. Results only show which technologies work, offering little insight into the crucial question of which types of services customers really need. "The trials have been more like safe demonstrations than real experimentation," charges Ralph DeMent, manager of strategic planning for distributed systems engineering at Digital Equipment (Littleton, Mass.). The phone compa-

US WEST

**"I expect significant ISDN deployment to occur throughout the United States during 1989—the U.S. is already pulling ahead of the Europeans and Japanese."**

Joe Miller
Director,
ISDN Technical Development

nies, he says, aren't willing to risk failure.

"That's an unfair criticism," US West's Miller responds. The applications first tested were simple and straightforward, he admits, but tests of more complex capabilities have grown out of users' suggestions. The Phoenix trial, he says, has 20 or more applications running—"and not all were foreordained," he says.

Aside from testing technologies and service, the trials serve the important role of fostering cooperation among vendors of ISDN products and network facilities. "The trials are a good forum in which to resolve incompatibilities," Bellcore's Felts says. "You can't just publish your interface and walk away." For ISDN to succeed in the United States, the telecommunications industry must get the computer industry to participate, "so both can win," Digital's DeMent adds. "They haven't done that very well so far."

**REMAINING BARRIERS.** The wait for standards, the search for services, and the difficulties of getting competitors to cooperate all slow the coming of ISDN. But even if these problems were immediately resolved, other issues would remain. Not the least of these is the need for the RBOCs to decide which features will make up the basic ISDN service and which will be offered as options. If too little is put into the basic package, it may not lure enough customers into the ISDN sphere. But adding too many features at the basic level will reduce the market for higher-priced options.

Intricately tied to this dilemma is the question of how much to charge for each type of service. The RBOCs must invest massive amounts of capital to convert their analog networks to digital, and they view ISDN as the primary vehicle with which they can recoup this cost. "State regulatory agencies are not inclined to let the RBOCs recover their costs through basic-service rates," says Walter G. Bolter, director of the Bethesda (Md.) Research Institute. "The agencies *are* willing to grant the RBOCs more pricing flexibility in other areas and services." Uncertainty over pricing makes it virtually impossible for business users to estimate future telecommunications costs.

Probably the biggest obstacle the public carriers must overcome in their pursuit of ISDN, though, is the physical overhaul of the U.S. phone network. The BOCs currently have about 89 million lines installed. Some 40 million of them are still tied to old analog switches, estimates Yo-Sung Cho, president of Integrated Network (Bridgewater, N.J.), which makes products that add digital capability to the analog switches. In addition, none of the digital switches operating in the network yet matches ISDN interfaces and software, except those in the RBOC trials.

As a result, ISDN will be implemented across the country in a piecemeal fashion, with islands of ISDN first installed wherever there is clear demand. "You'll have ISDN capability in Manhattan way before you have it in Idaho," Telenet's Holmblad says. These ISDN pockets may pose problems for businesses with offices in several regions, some with ISDN local switches and others without. In addition, different locations may have different services available. Even though the RBOCs all endorse ISDN standards, there is no guarantee that they will decide to offer identical services. In fact, "the RBOCs show signs of competing with each other," says analyst Perry of International Data.

The problem of a patchwork ISDN can be solved with an overlay network that allows access to remote ISDN switches, much the way a remote mainframe computer is tapped by attached terminals. This will undoubtedly be used in the United States, since there is no way to bring up ISDN switches simultaneously throughout the country. But the overlay approach will be less capable and more expensive than a ubiquitous ISDN network offering the same applications everywhere. The potential for a large number of dissimilar ISDN islands "represents the Achilles's heel of the technology," says Integrated Network's Cho.

PETER VIDOR

**PRIVATE ISDN.** Because it's not clear when ISDN will become available on the public network, some businesses are establishing their own private ISDN networks. Several companies already offer ISDN-compatible PBXs. These enable users to communicate among their scattered offices over the public network via non-ISDN digital links. This way, "users can merge with the public ISDN network whenever it becomes available," says Scott W. Augerson, senior product manager at Siemens Information Systems.

The first generation of these PBXs will be only partially compatible with ISDN. On the terminal side of the system, the interface will still be proprietary—allowing vendors to maintain a lock on the terminal equipment sold with their PBXs. Some observers predict that the desire to keep control of the PBX-terminal population will outweigh the vendors' incentive to be fully ISDN-compatible.

But Jack McDonough, ISDN terminal product manager at AT&T Network Systems (Andover, Mass.), disagrees. Referring to AT&T's Enhanced System/86 PBX, which currently has an ISDN primary interface and a proprietary terminal interface, he says: "There's no reluctance to relinquish the proprietary interface. We have to agree on standard interfaces if ISDN is going to take off."

BELLCORE

**"The ISDN-published standards sometimes permit vendors to implement different specifications. To ensure compatibility, Bellcore will issue technical references that recommend which of the options phone companies should use."**

Wayne Felts
Manager, ISDN implementation

Even if ISDN does catch on, its capabilities may still fall short of what's needed to handle growing communications needs. The ISDN basic transmission rate—two 64-kilobit-per-second voice-data channels and one 16-kbps signaling channel—"may not be adequate for desktop computer users of the 1990s," Digital's DeMent cautions. By that time, he says, most computers will offer sophisticated graphics—and the more detail there is in an image, the more information there is to transmit.

But Bellcore's Felts counters that the next generation of ISDN will meet future desktop computing needs by offering data speeds of up to two million bits per second. Most of today's network users have far less demanding requirements, he notes, and "ISDN beats the heck out of a 2400-bit-per-second modem."

While admitting the system's flaws, most ISDN backers maintain that the communications scheme is the best game in town. And they're determined to convince the U.S. market that ISDN is real, that it's coming soon, and that it will dramatically improve communications capabilities in ways that can't yet be imagined. "ISDN is a major evolutionary plateau," concludes Barry J. Eckhart, director of ISDN and planning at Northern Telecom. "Its arrival could be as significant as the advent of direct long-distance dialing." □

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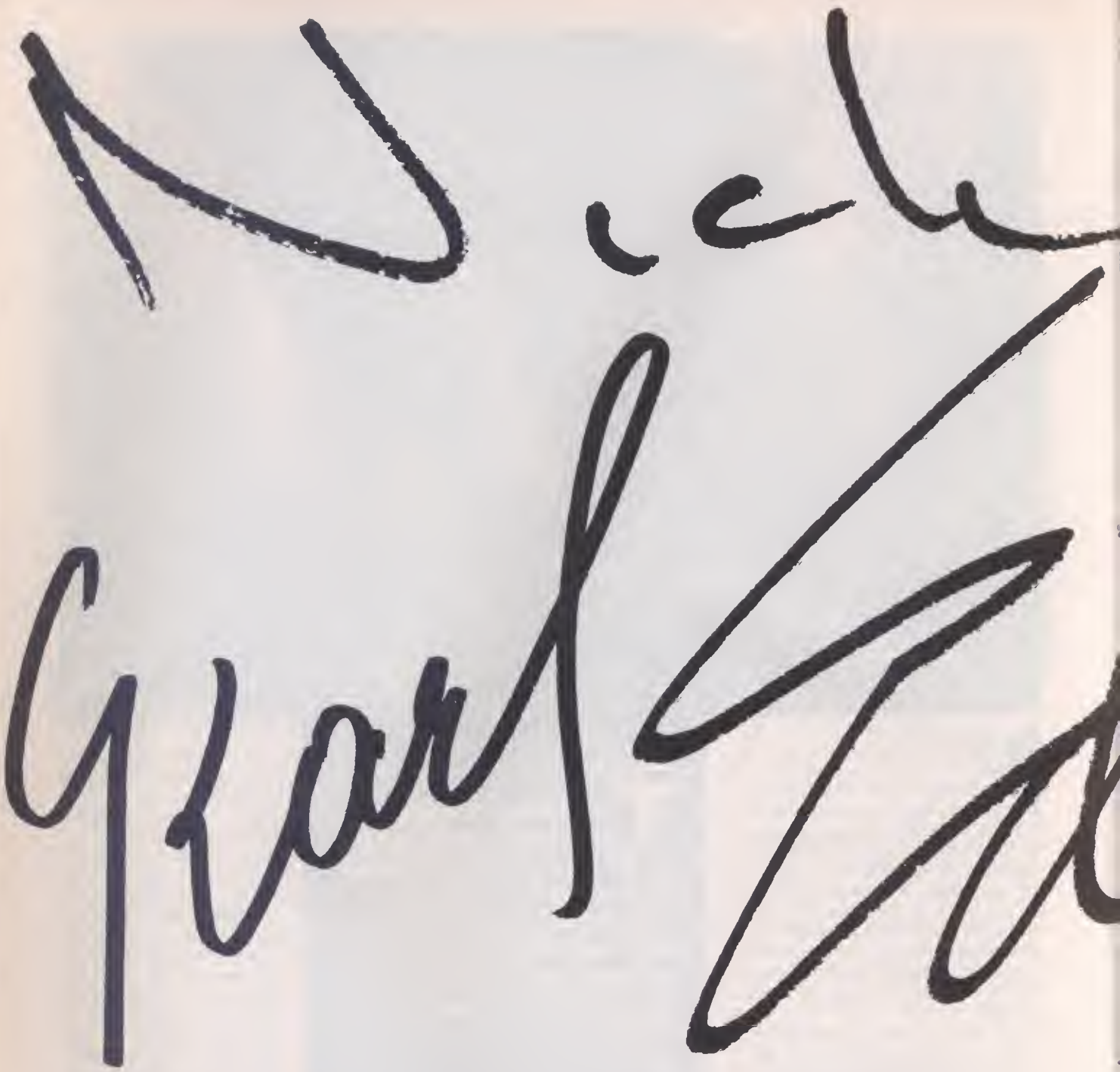

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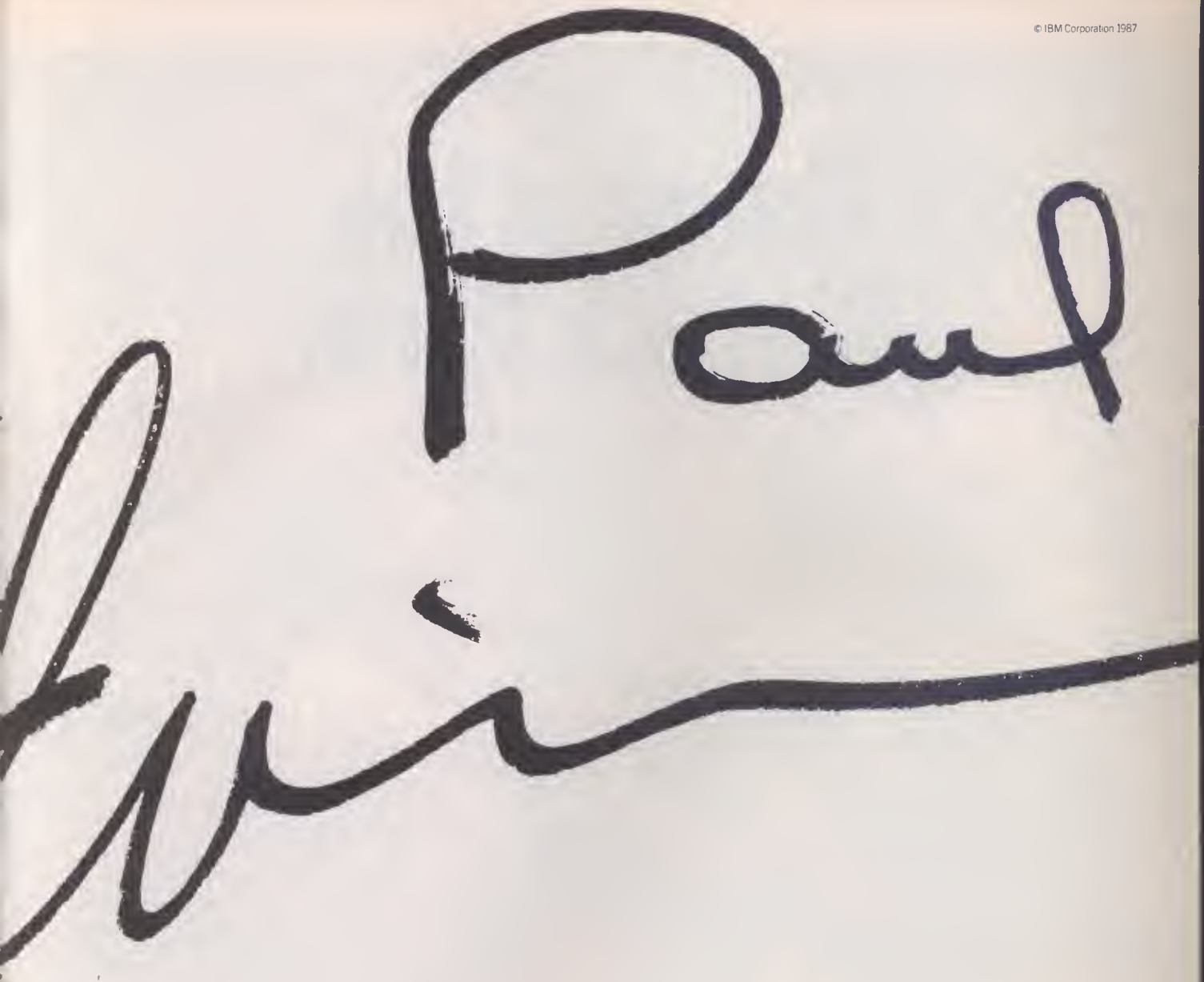

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# Dawn of the Biotech Farm

## *Animal health-care companies are out to corral a hefty share of a multibillion-dollar market*

BY H. GARRETT DEYOUNG

The U.S. farmer is on the ropes. Not only are farmers beleaguered with stiffening overseas competition, growing personal debt, and falling productivity, but thousands of them have apparently been unable to tap into the sort of new technology that has already offered relief to manufacturing industries.

Now a new industry is forming on the presumption that solutions to the farmer's decline may lie in animal health-care products derived through biotechnology. Some 450 companies around the world—including many of the biggest U.S. chemical and pharmaceutical producers—are developing animal-care products based on the new tools of molecular biology, such as gene splicing, according to Technology Management Group (TMG), a Norwalk, Conn., market-research firm. Their goal is to revolutionize livestock management on the estimated 2.2 million U.S. farms, which make up the world's largest animal-care market.

In many cases the products are outgrowths of corporate research in human health care. Products for animals are expected to move through regulatory channels faster than human therapies do, giving companies hope of earlier revenues.

Research in farm-animal health care is now focusing on several different areas:

- Inexpensive diagnostics that accurately spot diseases of potential danger to humans—trichinosis, for example—as well as diseases that could wipe out entire herds;
- Genetically engineered vaccines that are safer, more effective, and easier to use than conventional products;
- Growth hormones—genetically engineered proteins that may dramatically increase milk production in cows, reduce fat in hogs, and bring poultry to market faster; and
- Fertility hormones and embryo-manipulation techniques that will lead to more births and higher-quality livestock.

So far only a handful of the products have made it to market, and most still face stiff technical obstacles, such as questions about safety and production efficiency. Given farmers' financial plight, however, industry sources are convinced of a huge commercial demand. "Any product that enables farmers to raise animals at a reduced cost will have a tremendous market," says TMG president Manny Ratafia. "An increase of even one to two percent in farming productivity can mean millions of dollars across the industry."

**EARLY DIAGNOSIS.** Modern farms usually crowd large herds into small quarters. As a result, infection or disease can spread rapidly, wreaking economic devastation. Recent research in human diagnostics offers new ways to detect such diseases in their early stages, enabling the farmer to isolate the infected animal for treatment.

As in human diagnostics, the systems for animals analyze fluid samples, looking for abormal proteins that signal foreign cells or organisms. Among the most popular diagnostic systems, Ratafia says, are those based on enzyme-linked immunosorbent assays (ELISAs). These inexpensive kits use antibodies and enzymes to produce color changes that indicate the presence of invaders.

"Agricultural diagnostics is an untapped field," says Prithipal Singh, head of R&D at three-year-old Idetek, one of a growing number of companies specializing in the field. "It's at about the same stage that human diagnostics was during the late '70s." Idetek is now marketing diagnostic tests for both animals and crops (which use plant hormones to predict maturity and overall health). Now under development are diagnostics to detect drug residues in meat—a matter of growing consumer concern, Singh notes.

Idetek is one of three companies commercializing a blood test for trichinosis, a parasitic disease of hogs that occasionally infects humans. The other companies are Agritech Systems, and Difco R&D Center. In the Idetek system, an extract derived from trichina worms is grown in the laboratory, and a few drops of blood from the suspect animal added. If the animal is in-

*At Applied Animal Genetics, Gary Lindner (left) obtains as many as 15 calves per year from this prize Hereford.*

fected, antitrichina antibodies in the blood react with the extract and change color.

The Idetek trichinosis test is now being tried out in slaughterhouses. Using proprietary automated equipment, it can test 500 samples per hour, according to Singh, and costs about one cent per pound of meat. The company is also developing a low-cost trichinosis test for farm use, although Singh declines to give details.

Meanwhile, three-year-old Agritech is marketing some two dozen diagnostics, according to Jeanne W. Eagle, director of corporate development and planning. The products are designed both for high-volume laboratories, which typically run several hundred samples per hour, and for field use, where only one or a few animals are tested at a time. For example, the company has designed a line of fast, disposable ELISA field tests that diagnose feline leukemia and canine heartworm. Other diagnostics include tests for swine pseudorabies, a viral disease of the nervous system; brucellosis, which causes high abortion rates in cattle; and poultry salmonella. Also under development are systems to detect feed contaminants.

Other diagnostics on the market or in development check for such diseases as infectious anemia; bluetongue, a fatal viral infection of sheep and cattle; and avian retrovirus, a gastrointestinal infection that now costs the world's poultry industry at least $1 billion a year.

**WARDING OFF DISEASE.** Probably the hottest area in animal health care is in products that arm a young animal's immune system. The first genetically engineered animal vaccine, introduced by Molecular Genetics in 1983, protects against scours, which causes diarrhea, dehydration, and death in calves and piglets at an annual cost to U.S. farmers of $500 million. Since then such corporate giants as American Cyanamid, Upjohn, and International Minerals & Chemicals have stepped up their development of vaccines to prevent such disorders as bovine mastitis, an udder disease that diminishes milk production; Rift Valley fever, which causes abortions in sheep, goats, and cattle; and foot-and-mouth disease (FMD), a viral infection that has been eliminated in the United States but still costs other countries more than $50 billion a year in lost livestock.

Worldwide the agriculture industry

PHOTOGRAPH BY CHRISTOPHER SPRINGMAN

now spends more than $1 billion a year on conventional vaccines known to be only intermittently effective. These vaccines, made from killed or weakened viruses, trigger the immune system by prompting the production of antibodies, which usually last throughout an animal's life. But killed-virus vaccines often fail to provoke an immune-system response to the live virus, and weakened-virus vaccines may actually infect the animal with the disease they were designed to prevent. For example, some FMD outbreaks have been linked to the use of this type of vaccine.

New biotechnology tools offer alternatives. Molecular Genetics's vaccine against scours is based on monoclonal antibodies—proteins that are designed in the lab to attach only to specific microbes. Given orally to calves during the first 24 hours of life, these antibodies prevent scours bacteria from attaching to the intestinal linings. The vaccine is now available in the United States, Canada, and Ireland, according to executive vice-president Charles C. Muscoplat, and is being studied by other European countries. Molecular Genetics is also developing an antiscours vaccine for piglets and is testing vaccines against Rift Valley fever, mastitis, and papilloma, a disfiguring disease that affects the value of show animals.

**HARMLESS VACCINES?** Another biotech approach to vaccines relies on harmless proteins found on the surface of the virus. These subunits trigger an immune response in the entire organism. Genentech is working with the Department of Agriculture to develop a subunit vaccine against FMD, whose world market would be larger than for any other animal or human vaccine, according to TMG's Ratafia. Molecular Genetics is also working on subunit vaccines, but development has "proved to be more difficult than we'd originally thought," Muscoplat says. Subunit vaccines often fail to elicit a response because the body does not perceive them as natural invaders.

Such difficulties are leading some biotech companies to pursue other vaccine technologies. Applied Biotechnology, for example, is developing vaccines from live, genetically engineered organisms, which are both safe and effective, according to business development manager Ruth Emyanitoff. It may be possible, she says, to engineer genes for certain proteins into the harmless virus known as vaccinia. In the body, vaccinia prompts the animal to produce antibodies against the proteins the virus manufactures. Applied Biotechnology is now using the technique to develop a vaccine against porcine pseudorabies, an often-fatal disease that prevents interstate shipment of infected animals and costs U.S. farmers about $60 million a year.

For such a vaccine to be most useful, however, it must be possible to distinguish between a virus that is being used as a vaccine and a virus that signals infection. One solution being studied by Applied Biotechnology is to add a marker—an engineered protein that would not be present in an unvaccinated animal—to the vaccine. The protein would be detected by a simple diagnostic test and would unmistakably identify a vaccinated animal. The company is still testing the concept and has no product on the market. "We're dealing with live organisms here and want to proceed cautiously and responsibly," Emyanitoff says.

Upjohn, too, is working on a pseudorabies vaccine. An experimental version is now being tested in animals in six states, and commercialization is expected by year end, says spokeswoman Maury Ewald. Upjohn researchers have engineered a marker virus that lacks two genes—the one that causes the disease and one that will identify the vaccine. "Since the protein that this second gene encodes is missing, the animal does not produce antibodies to it," Ewald explains. "The lack of that antibody means that the pig has been vaccinated." The vaccine will be produced by Diamond Scientific (Des Moines).

*Rising world demand for meat could mean big sales of new growth hormones for U.S. livestock.*

**NEW TREATMENTS.** Recent advances in immunology have already led to promising new therapies for human diseases. The biological compounds interferon and interleukin-2, for example, have emerged as potential cancer treatments. Now major drug companies such as Schering-Plough (Madison, N.J.) and Hoffmann-LaRoche (Nutley, N.J.) are studying how these molecules fight disease, with an eye to possible veterinary applications.

Smaller companies too are pursuing the immunological approach. Immuno Modulator Labs, for example, markets interferon to treat shipping fever, an often-fatal viral disease of cattle, and equine influenza. The products are sold only in Texas now, but the company is seeking FDA approval for national marketing, according to vice-president George V. O'Bleness.

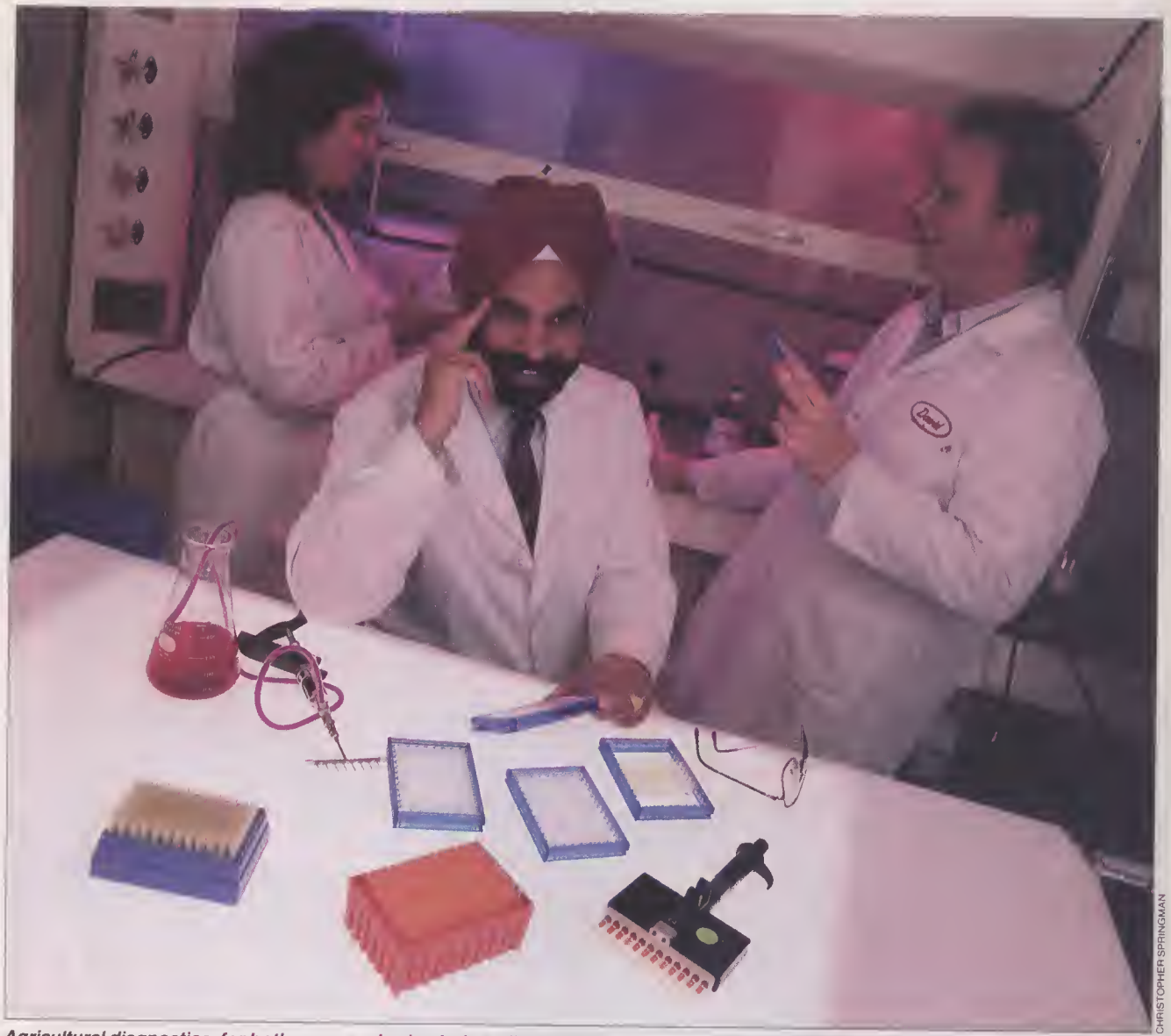
Interferon has demonstrated several intriguing benefits in animals, O'Bleness says. The substance appears to promote wound healing and to treat parasitic diseases, for example. Immuno Modulator Labs is also studying low doses of interferon as a potential replacement for antibiotics and has patented a technique in which interferon is used to stimulate the appetite and increase the feed efficiency in sick animals—an obviously important aid for recovery.

**MORE MEAT NEEDED.** Worldwide consumption of meat will double by the year 2000, TMG estimates. To meet this demand, farmers will need to produce larger hogs, poultry, and cattle. As a result, Ratafia says, worldwide sales of genetically engineered growth hormones, which are expected to be more plentiful and less costly than those derived from slaughtered animals, could eventually reach $5 billion. Several companies are now in the early stages of engineering growth hormones for poultry. These proteins could reduce maturation from eight weeks to six, thus reducing farmers' costs by 25 percent. Another protein, called porcine growth hormone, under development by Monsanto, IMC, and others, reportedly results in leaner, faster-growing pigs.

For various technical, regulatory, and economic reasons, most growth hormones are still several years from commercialization. Closer at hand is a genetically engineered growth hormone for dairy cows, called bovine somatostatin (BST). Cows given regular BST injections produce an average of 20 percent more milk. "That makes BST an important management tool," says Lee A. Miller, vice-president and general manager of Monsanto's animal-sciences division. "The dairy farmer can now produce the same amount of milk with fewer cows and less feed and equipment.

Monsanto's BST (produced in genetically engineered bacteria developed by Genentech) has received FDA approval for safety in humans and is now being readied for animal trials near St. Louis and at Cornell University (Ithaca, N.Y.). Monsanto expects to commercialize BST during 1989–92, followed shortly by the porcine hormone. The company is also designing a proprietary drug-delivery system that calls for injections only twice a month rather than daily. Other BST developers include Upjohn, which is collaborating with biotechnology company Amgen to produce it in Upjohn's Kalamazoo, Mich., facility, and BioTechnology General, which is collaborating with American Cyanamid. The hormone is now in early animal trials, Ewald says, and could reach the market by 1990.

The nation's long-standing oversupply of milk, however, could stall BST's com-



CHRISTOPHER SPRINGMAN

*Agricultural diagnostics, for both crops and animals, is an "untapped field," says Idek's Prithipal Singh.*

mercialization. Opponents predict that increased milk production will further depress milk prices, a result that would hit the small dairy farmer hardest. But Monsanto's Miller points out: "No one suggests that we need to produce more milk. What we need is to produce milk more efficiently, regardless of herd size, and that's what BST will do."

**ENTER THE SUPERCOW.** The steady decline in the number of working U.S. farms will make it necessary not only to preserve valuable animal genes, but also to increase the economic and nutritional value of the nation's livestock. As a result, several companies are now offering biological products that manipulate animal fertility cycles. For example, it is becoming commonplace to diagnose pregnancy in dairy cattle at an early stage, thus alerting the farmer to the animal's increased milk production. Other developments include the production of two embryos from a single fertilized egg, methods for increasing herd size, and the determination of embryo sex—an important bit of information, given that beef ranchers typically want to maximize the number of male animals, while dairy farmers prefer females.

An illustration of this kind of technology came early this year, when Integrated Genetics received FDA approval to test bovine follicle-stimulating hormone (bFSH), a genetically engineered protein that plays a vital role in cattle reproduction. The world market for the hormone, according to the company, is about $200 million a year.

A bFSH-treated cow produces as many as six eggs during ovulation, rather than just one. The eggs are fertilized, either in the cow or in vitro, with sperm from a genetically valuable bull, then placed into surrogate mothers—less valuable cows who carry the embryos to birth. This superovulation technique could dramatically increase the number of prize herds around the world. Commercialization is expected next year, according to Integrated Genetics spokeswoman Nan DuCharme. Tests are now under way by Granada R&D Ventures (Houston), an animal-genetics specialty company.

In another application, bFSH could enable large numbers of genetically desirable embryos to be shipped to other countries, many of which strictly limit the importation of live animals. These embryos would not only carry the desirable genes from their natural parents, but would also receive certain beneficial characteristics—resistance to indigenous diseases, for example—from the

surrogate mother's immune system.

Another company that hopes to carve out major foreign markets in embryo transfer is Applied Animal Genetics. The company is now negotiating with customers in China (as well as in the United States), according to Gary M. Lindner, vice-president and chief operating officer. Livestock in many countries, he says, tend to be genetically inferior to U.S. breeds. Hogs are often smaller, for example, and less efficient at converting feed to meat. And Chinese dairy cows typically produce only about 600 pounds of milk per year—half as much as holsteins in the United States.

Working with natural bFSH derived from swine pituitary glands, Applied Animal Genetics performs thousands of such transfers every year (mostly in dairy and beef cattle) for "all kinds of customers, from single-family operations to big corporate farms," says Lindner. The company has developed a proprietary embryo-freezing technique, in which the fertilized egg is developed for about seven days, then dehydrated and slowly brought to below freezing. The embryos—each about the size of a speck of dust—are put in liquid nitrogen for shipment. With such a strategy, TMG's Ratafia says, "an entire herd can be transferred in the form of frozen embryos for less than the price of transferring one live animal."

Precise market figures for bFSH are scant, since there is now no comparable product, DuCharme acknowledges. However, in 1985 some 100,000 cows were superovulated with a pituitary extract derived from slaughtered animals at a per-dose price of $25, she notes. "But it's very difficult to obtain pure hormones from animals," she explains, "since they have to be separated and purified from a mixture of other proteins. Genetic engineering gives us an almost unlimited supply and at less cost."

As with interferon and other animal health-care products, bFSH spun off from research in human health care—in this case, from Integrated Genetics's human-fertility research, conducted with Serono Laboratories. Integrated Genetics is also preparing to enter trials with fertility hormones for thoroughbred horses and with porcine hormones to increase piglet birthrates.

The growing interest in animal fertility has itself given birth to a number of companies specializing in drug-delivery systems. These outfits are developing methods by which animals can safely utilize new and existing hormones. For example, 15-month-old InnoVet is now applying two proprietary systems developed by Pharmatec to deliver estrogen and other conventional hormones.

In one technique, hormones and other compounds are encapsulated in a starchy material called cyclodextrin, then injected into the animal. The encapsulated molecules are slowly released into the bloodstream over a period of weeks or months. The biocompatible cyclodextrin prevents rejection by the animal's immune system. Although InnoVet is not now working with genetically engineered molecules, the company sees such an approach as logical in the future, according to chairman Mark Golden.

So far InnoVet has no products. But, Golden says, the company expects by early next year to offer a rodenticide that controls birthrates. The system uses a hormone to sterilize female rats, which experience six or seven fertility cycles a month and give birth to seven or eight babies at a time. InnoVet will market the product as an alternative to poisons, many of which have become ineffective against the amazingly adaptable pest.

*Molecular Genetics's Charles Muscoplat administers a vaccine against scours, a fatal intestinal disease.*

No one, of course, suggests that biotechnology alone will solve all the problems—many of which are based more in economics and politics than in technology—that now beset the U.S. farmer. Still, many of the new products and processes arising from biotechnology clearly offer farmers a cost-effective opportunity to step up productivity, reduce losses, and thereby gain more control over their future. To the extent that farmers seize such opportunities, biotechnology may offer new hope for America's heartland—and for the hundreds of companies that have invested in its future. □

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## THE PLAYERS

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**Amgen**
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**Applied Biotechnology**
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**Biotechnology General**
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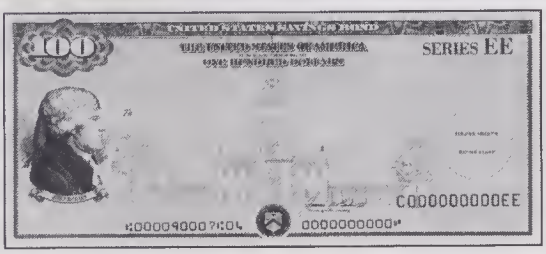


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# Optical Memories Vie for Data Storage

STEVE NIEDORF

*Dave Davies, head of 3M's optical recording project, says more than 20 companies are evaluating 3M's erasable optical disks.*

A high-stakes battle is brewing in computer-data storage among new optical challengers to conventional magnetic disks. Optical memories hold huge amounts of data at relatively low cost. The first wave of optical data disks, which are just starting to gain commercial acceptance, enable personal-computer users to store hundreds of megabytes of information permanently (one megabyte is roughly equivalent to 1000 typed pages). Coming soon, however, are erasable optical disks, which will combine the voluminous capacity of optics with the reusability of traditional magnetic media.

Yet what a half dozen years ago looked like a cakewalk for optical storage has turned into a horse race with revitalized magnetic technology. Capacities of hard magnetic disks have risen steadily. In January, Maxtor began shipping a 5.25-inch hard-disk drive holding an impressive 760 megabytes. Hard magnetic

BY JEFF HECHT

ROGER RUSSMEYER

◆ ***Magnetic drive maker Maxtor is preparing optical units. "Whichever technology ultimately dominates, we're going to be there," says president James McCoy.***

drives access data faster than their optical counterparts. And magnetic floppy disks—though offering tiny capacity compared to optical disks—are dirt-cheap.

Optical disks first appeared in the early seventies as a way to distribute video programs to homes. Engineers at the Dutch electronics giant Philips and the U.S. entertainment conglomerate MCA took similar approaches: reading spots on a prerecorded rotating disk with a tightly focused laser beam. The biggest success of optical disks started as a spinoff of videodisk development. Philips and Sony developed the compact disk (CD), which provided unprecedented audio fidelity.

It proved a simple step from digital audio to digital computer data, so the plain CD gave birth to the CD read-only memory (CD-ROM). These platters can store up to 600 megabytes of data, enough for all the text in Grolier's 24-volume Academic American Encyclopedia. The Philips-Sony format is becoming an accepted standard in electronic publishing. Other companies, including Lotus, Microsoft, and McGraw-Hill, also publish CD-ROM data bases and references. CD-ROM technology benefits from the economies of scale of CD production, and Philips and Sony are trying to spawn other ventures.

Early in the decade, optical disks were seen mainly as potential adjuncts to mainframe computers. A handful of companies built 12-inch drives to handle 1000 megabytes or more. Today, however, optical-disk companies are targeting the high-volume market of personal-computer peripherals.

Technical and business factors have interacted to shape the optical data-storage market. A key issue has been the nature of light-sensitive materials needed for optical recording. The writing laser beam permanently changed first-generation materials, mostly metal films, forming tiny pits or spots on them that reflected the read beam differently. Once data is written, it is recorded for the life of the disk. Such write-once, read-many-times (WORM) technology has its advantages. It elimi-

## THE OPTICAL-DATA-STORAGE MARKET

(Figures include disk drives only, not disks.)

### CD-ROM

Compact-disk read-only memory

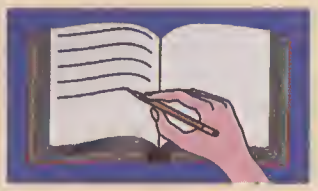
| Year | Units (000) | Sales ($M) |
|---|---|---|
| 1986 | 40 | 80 |
| 1988 | 250 | 150 |
| 1990 | 690 | 150 |

**COMPANIES**

**Hitachi**, San Bruno, Cal., (415) 872–1902
**Laser Magnetics Storage International**, Colorado Springs, Colo., (303) 579–0460
**Philips**, Mahwah, N.J., (201) 529-3800
**Sony**, Park Ridge, N.J., (201) 930–1000
**Toshiba**, Santa Clara, Cal., (408) 727–3939

### WORM

Write once, read many times—not erasable



| Year | Units (000) | Sales ($M) |
|---|---|---|
| 1986 | 10 | 20 |
| 1988 | 50 | 100 |
| 1990 | 300 | 210 |

**COMPANIES**

**Kodak**,* Rochester, N.Y., (716) 724–1336
**IBM**, Endicott, N.Y., (607) 755-0123
**Information Storage**, Colorado Springs, Colo., (303) 579–0460
**Maxtor**, San Jose, Cal., (408) 942–1700
**Optimem**, Sunnyvale, Cal., (408) 737–7373
**Optotech**, Colorado Springs, Colo. (303) 570–7500
**Pioneer**, Long Beach, Cal. (213) 639-5050
**Toshiba*** Santa Clara, Cal. (408) 727-3939
*large disk, not intended for PC use

### HYBRID

Reads pre-recorded disks (e.g., CD-ROM) and records on writable disks

| Year | Units (000) | Sales ($M) |
|---|---|---|
| 1986 | 0 | 0 |
| 1988 | 1 | 5 |
| 1990 | 1 | 1000 |

**COMPANY**

**Optimem**, Sunnyvale, Cal. (408) 737-7373

### ERASABLE

Can overwrite data, similar to magnetic drives

| Year | Units (000) | Sales ($M) |
|---|---|---|
| 1986 | 0 | 0 |
| 1988 | 1 | 5 |
| 1990 | 70 | 140 |

**COMPANIES**

**Matsushita**, Secaucus, N.J., (201) 348–7777
**Philips**, Mahwah, N.J., (201) 529-3800
**Sharp**, Mahwah, N.J., (201) 529-8200
**Sony**, Park Ridge, N.J., (201) 930-1000
**Verbatim**, Sunnyvale, Cal., (408) 773–5777

SOURCE: COMMUNICATIONS PUBLISHING INC.

nates, for example, the accidental overwriting of a vital file and can provide indelible audit trails for financial records. A few developers went so far as to claim that optical storage was cheap enough to make disk reusability irrelevant.

But optical-disk drives have sold slowly for a number of reasons. It has taken time to develop the special interfaces and software needed to use the drives with personal computers. Moreover, only a small number of PC users need the 100 megabytes or more that the optical drives offer—or want to pay the price of $2500 and up. Other potential buyers are probably holding out for erasable optical disks, which are persistently rumored to be available soon.

Some work continues on optical memories for mainframe computers. Eastman Kodak, for example, recently introduced a system that stores *one trillion* bytes on four 14-inch disks. Other major players, however, have dropped out of the mainframe market. One casualty was Alcatel Thomson Gigadisk, a French venture originally funded by Thomson-CSF, which offered one of the first 12-inch drives. And Storage Technology Corp., which spent tens of millions of dollars on a multibillion-byte system, abandoned the program by 1986, while reorganizing under Chapter 11 bankruptcy. Other optical-storage companies sought other markets. Drexler Technology (Mountain View, Cal.), for example, shifted its attention from large disks to smaller-capacity cards.

***An optical disk carrying sensitive data can be removed from its drive and locked in a secure place.***

Meanwhile, action is heating up in the market for optical-disk drives for personal computers and workstations. Most of these units store 100–300 megabytes on each side of a 5.25-inch disc. Prices for relatively low-capacity systems start at around $2500, and disks cost $60–$250. At the high end, Information Storage Inc. plans this year to start making systems priced around $4000. ISI has already established itself in the optical-disk field,

**Optical recording heads are far enough away from the disk surface to prevent the hard-disk owner's nightmare: a "head crash" that destroys head, disk, and data.**

claiming to have sold more than 2000 lower-capacity drives since introducing them two year ago.

Another firm, Optotech, has been offering 400-megabyte drives for about as long as ISI. Optotech offers a controller to run four drives at once, giving immediate access to 800 megabytes. Other companies also make these products, but the biggest splash came in April when IBM announced a 200-megabyte drive. In effect, the computer giant put its stamp of approval on the concept of optical-disk storage for small computers. IBM's drive, priced at $2950, works with the company's new Personal System/2 computers and existing PC/AT and XT models.

Disks that combine huge capacity with reusability may soon arrive commercially. Sony plans to ship evaluation models in October and production quantities next year. And it won't be alone. Erasable drives will probably come out from Japanese competitors such as Sharp and Matsushita as well as from U.S. magnetic-drive maker Maxtor. Industry observers caution, however, that erasable systems most likely will not be available to end user in large numbers until 1989 or 1990.

Sony's erasable drives, like most others in development, use magneto-optic technology. The storage medium is a thin metallic film. The recording of data requires both a laser and a magnetic recording head. For each digital bit, the laser beam heats a small area of the film. This warmed spot takes on the magnetic field direction—i.e., north or south—imposed by the recording head. For a readout, a weaker laser beam passes through the film and hits a reflective surface underneath. The returned beam's polarization differs depending on whether it has struck a spot magnetized north or south. This magnetization can be reversed simply by laser heating the spots on the disk in the presence of the opposite field.

The acknowledged leader in magneto-optics is 3M. More than 20 companies are evaluating samples of 3M's magneto-optics, says Dave Davies, general manager of 3M's optical recording project. So far 3M only makes the disk in small quantities. One problem has been stability: Unprotected magnetic materials can rust.

While working on magneto-optic drives, Philips and Matsushita are also pursuing a different method of erasable optical storage, based on phase-change materials. Laser light converts spots on a thin film from a highly reflective crystalline state into a duller amorphous material. Another, more powerful beam can reverse the process, changing the spot back to crystalline form. Matsushita demonstrated a phase-change memory in 1983 and has licensed some crucial patents held by Energy Conversion Devices (Troy, Mich.), but it has yet to announce any products.

The durability of both magneto-optic and phase-change materials suffers from the need for repeated thermal cycling. A number of other technologies are being developed. Quantex (Rockville, Md.), for example, has developed a family of phosphors that store information via a phenomenon called electron trapping. Recording data requires a beam of visible light, which illuminates spots on the disk surface. This beam promotes the phosphor's electrons to a state of higher energy, where they remain trapped. To read back the information, an infrared laser illuminates the disk surface. Points that had previously been hit with the light beam glow. That's because the infrared photons nudge some of the energized electrons out of their traps, causing them to release energy as light. The traps can be simultaneously refilled with a visible beam that accompanies the infrared one.

The continuing development of erasable optical materials is actually slowing the initial introduction of commercial products. Because the nature of the recording medium is still uncertain, present design efforts might be wasted. "It will take a year or two for the first erasable optical drives to get into the pipeline," 3M's Davies says, citing the need for interfaces and software to access data on the disks. "It will be 1990 before there's anything like a business here," he adds. "These things always take longer than anybody imagines."

The need for special software and interfaces has delayed both CD-ROMs and WORM drives. The problem with CD-ROMs is accessing the large volume of data. For WORM drives, this is complicated by the inability to overwrite data. The problems may not be as severe for erasable optical drives. If an erasable disk looks like a hard magnetic disk to the software, attachment will be similar.

Recent advances in magnetic memories have somewhat diminished the advantage of optical disks. Indeed, the first erasable optical disks will fall short of the performance of hard disks—especially in speed. Sony's planned erasable drive will read out data at about 4 megabits per second, versus 10 megabits per second for a typical hard disk. Before the data can be read, it must be found on the disk. Magnetic hard drives can do this in about 30 milliseconds, but first-generation magneto-optic units will take three times as long. "Optical disks are not going to compete in access time or data rate in the beginning," says Gordon R. Knight, who heads optical-drive development at Maxtor. Adds Maxtor president James McCoy: "It's a win-win situation for us. Whichever technology ultimately dominates, we're going to be there."

Despite their relative sluggishness, optical drives have the edge over magnetic ones in several ways. Unlike magnetic hard disks, optical disks can be taken out of their drives. Thus, a single drive can hold more than one disk's worth of data. Moreover, a disk containing sensitive information can be removed from the drive and locked in a safe place. One optical disk can back up an entire hard disk faster and more easily than multiple floppy disks or tape. Although the difference in removability makes cost per megabyte difficult to compare, prices for equal capacity drives are roughly comparable.

Another technical attraction of optical disks is greater durability. Stray electromagnetic fields that corrupt data on magnetic disks cannot affect optical ones. And the optical recording heads are far enough away from the disk surface to prevent the hard-disk owner's nightmare: a "head crash," where the read-write head scores the disk, destroying head, disk, and data.

Most developers of WORM and erasable optical drives are sticking to the 5.25-inch-diameter disk format widely used in the microcomputer industry. An exception is Verbatim, a Kodak subsidiary, which plans to produce evaluation models of 3.5-inch drives early next year. The smaller disks will be aimed at users who don't need the 325-megabyte-per-side capacity of products such as the Sony magneto-optic drive. Verbatim's 3.5-inch cartridges will hold more than 50 megabytes, the company says.

Ideally, formats for both write-once and erasable disks will be standardized so that disks will be interchangeable among

## Optical-Storage Categories

Optical storage has many variants. Many are used to store audio and video signals, not computer data per se. The major types:

- **Videodisks:** Prerecorded disks (usually 12 inches in diameter) that store video programs in analog form, which are mass-produced by a pressing process. Applications include home entertainment, education, and displays. Some types allow random access to different points on the disk; others allow only straight-through playback.

- **Interactive video:** Videodisks encoded to interact with a computer. Typically used for training and displays, they can show pictures in many different sequences at user command.

- **Compact disks:** 12-centimeter (4.7-inch) disks that store prerecorded digital audio with extremely high fidelity. CDs are mass-produced by pressing techniques similar to those used for videodisks. Their enthusiastic acceptance by consumers has been the biggest success story for optical-storage technology. The CD format is a hardware standard jointly developed by Philips and Sony, which they have licensed to audio-equipment manufacturers around the world.

- **CD-ROM** (Compact disk, read-only memory): 12-centimeter disks that store prerecorded digital data in the CD format, but are intended for use directly by computers. A single CD-ROM holds about 600 megabytes, enough for a 24-volume encyclopedia. Major uses are for electronic publishing of large data bases.

- **CD-I** (Compact disk interactive): Modified compact disks that store some video as well as audio and digital data. Designed for interactive video applications by Philips, they allow only limited motion. They are intended for home use, training, and interactive displays. CD-I players and disks are not yet on the market.

- **CD-Video:** Full-motion video programs stored in CD format. Intended for the consumer market, this format was designed primarily for music videos, which are now distributed largely on videotape. Each disk can hold 5 minutes of video along with 20 minutes of digital audio.

- **DV-I** (Digital video interactive): A method of compressing full-motion video for recording on CD-ROMs or other digital media, developed at RCA laboratories. Its main attraction is the vast expansion of the video capabilities of the CD format.

- **WORM** (Write once, read many times): Optical disks that allow users to record data, but not to write over existing data. The main action now is in disk drives for personal computers that have a capacity of 125 megabytes to one billion bytes. Most disk-drive designs accept double-sided disks, but require that they be flipped over manually to read the second side.

- **Erasable disks:** Disks that let users read, write, erase, and write over data. Capacity is similar to WORM disks. Most attention is devoted to 5.25-inch drives for personal computers, with some work on 3.5-inch versions. The first generation of products, expected next year, will use magneto-optic technology.

- **Laser cards:** Credit-card-sized plastic cards with a strip of optical recording material that holds several megabytes. They are patented by Drexler Technology, which claims more than 20 licensees.

drives. Unfortunately, it looks as though multiple standards will prevail. The American National Standards Institute (Washington, D.C.) is working to establish two separate—and incompatible—formats for 5.25-inch disks, as well as a third standard for 3.5-inch disks. The good news is that each of these formats accommodates both WORM and erasable disks. This opens the possibility for a multifunction drive that reads and writes on different types of optical disks. One maker of WORM drives, Optimem, has already announced plans to make a multifunction 5.25-inch system.

With the optical-disk market still young, pricing remains on shaky ground. WORM drive prices seem comparable to high-end hard disks. Prices for erasable drives are less easy to gauge. With exchange rates uncertain, Sony cautiously announced a tentative price in yen—roughly equal to $7000 at the time. Other observers expect erasable optical drives to be priced 25–50 percent higher than magnetic drives of comparable capacity, but market forces remain to be heard.

The impact of optical technology on the data-storage market is a matter of speculation, and there are enough variables to cloud anyone's crystal ball. Price, performance, and reliability—all factors crucial to user acceptance—have yet to be firmly established. Moreover, both optical and magnetic technologies are evolving. So are markets and uses for personal computers and workstations. The greater use of graphics is likely to push memory needs upwards. On the other hand, an increasing number of computer users are hooking up to networks with large, on-line files, reducing the need for storage on the user's own disks. And not all optical-disk applications need be in the office. Magneto-optic drives might be rugged enough for use in airplanes, automobiles, and industrial sites where conventional magnetic drives couldn't survive, says Verbatim marketing manager Chandran Cheriyan.

Most market analysts have been consistently overoptimistic in forecasting optical-storage development and sales. Industry newsletter *Optical Memory News* grandly proclaimed 1985 to be the "year of the erasable optical disk"—a label that turned out to be at least three years premature. Optical-disk drives are now about to be put to the acid test of the marketplace. Their most likely early roles will be to back up hard disks, store archives, and retrieve information from large data bases. Unless WORM and erasable technology merge in dual-function drives, they will compete with each other as well as with magnetic disks. Many observers expect erasable disks to dominate and WORM drives to occupy only niche markets, such as the storage of sensitive financial data, where it's important to keep a permanent log of transactions. □

*Jeff Hecht is a free-lance writer based in Newton, Mass.*

# THE NEWEST MICROCOMPUTERS: STRATEGIES FOR MACINTOSH OWNERS

Last month we noted that IBM's recently announced operating systems and interface will make PCs work more like Apple Macintoshes. But what about the newly announced Macs—the Macintosh SE (system enhanced) and Macintosh II (the "open Mac")? What improvements do they offer? Are they becoming more IBM-PC-like? What should current Macintosh owners do with their machines?

Over the next few years Mac users will be spared the chaos that will plague the MS-DOS–OS/2 world. For one thing, slow PC-software development and hardware confusion are likely to allow the Macintosh to maintain its nearly two-year lead in applications software over the IBM PC. For another, the central processors that drive the Macintoshes—the Motorola 68000 and 68020—can run the same software, unlike the diverse chips in IBM's new machines. In the long run, the 68020 will supplant the 68000 because it can power vastly more memory—4096 megabytes compared with 16—and therefore far more sophisticated programs. For now, however, the main functional difference between the two chips is speed: The 68020 is about four times faster than the 68000.

The various Macintosh models do suffer from some incompatibility, however, largely because Apple has developed different versions of its read-only memory (ROM) for each new model. There are now four separate ROMs: an original 64-kilobyte version, a 128-KB ROM, and two 256-KB ROMs. These ROMs contain programs that control the distinctive Macintosh user interface. The original 64-KB ROM was built into the 128-KB and 512-KB Macintoshes. The 128-KB ROM was introduced with the Mac Plus and is also used in the Macintosh 512K enhanced. Both the Macintosh SE and Macintosh II have a 256-KB ROM, but not the same one. The most important difference is that the Mac II ROM has full support for color.

Although most existing software still runs with the 64-KB ROM, an increasing proportion of programs require routines that were first built into the 128-KB ROM, such as supporting characters that are a fraction of a pixel. Because very few Mac IIs have yet been sold, virtually no software requires its new 256-KB ROM, but forthcoming programs will rely on this latest ROM and will not run correctly or at all with older versions.

by Cary Lu and Ellen W. Chu

**THE NEW MACINTOSHES.** The same size and shape as earlier Macs, the Macintosh SE is a reworked version of its predecessors. Its most significant new features are a single expansion slot and provision for two internal disk drives—either two 800-KB floppy-disk drives or one 800-KB floppy- and one hard-disk drive (you can now get one from Apple that holds 20 megabytes; drives with 40 megabytes or more should be available soon). The expansion slot will be most often used to support a larger display screen or a speedup board. It can also accept an Intel 8086 board to run MS-DOS software. Changes in hardware and ROM mean the SE runs a little faster than earlier Macintoshes—about 15–20 percent faster—but its built-in fan makes it a lot noisier than less powerful models.

***Slow software development and hardware confusion on the IBM PC are likely to allow the Macintosh to maintain its nearly two-year lead in applications software.***

Another change is the introduction of the Apple Desktop Bus for connecting the keyboard, mouse, and other pointing devices. This bus is incompatible with keyboard and mouse accessories built for earlier Macs, although it supports up to 16 different devices. Also, for the first time Apple is selling the keyboard separately from the main computer. You can either buy one with 81 keys, resembling the Mac Plus layout, or an "extended" keyboard with 15 additional function keys, which is a near replica of IBM's latest keyboards.

The SE runs the core 1987 software, but it will begin to fade in late 1988 and 1989. Programs introduced at that time, however, will require the hardware of a Macintosh II.

The design of the Mac II has taken a different turn. Using Motorola's 68020 processor and 68881 numeric coprocessor, the Mac II runs about four times faster than all other models. It will be Apple's flagship until late 1989 or 1990, when it will likely be displaced by a more powerful model. Unlike previous Macs, the computer comes in three parts—chassis, keyboard, and monitor—that must all be purchased separately. The low-profile, six-slot chassis takes up nearly twice the space of earlier Macs and accepts a variety of accessory boards, including 80286 and 80386 processors for MS-DOS and OS/2 software.

The same two keyboards now available for the SE also work with the Mac II. Apple is offering a black-and-white or a color monitor, both 12-inch screens with 640 by 480 pixels (compared with the previous 9-inch screen with 512 by 342 pixels). To use either, you must also purchase a separate video card. In addition, a 5¼-inch MS-DOS disk drive will be available for those who need to read and write IBM PC–compatible disks. Eventually, the Mac II will be able to read and write MS-DOS–OS/2 3½-inch disks without accessories.

All these features make Mac II more PC-like than any of its predecessors. This leads to greater flexibility, but also to higher price: A fully equipped Mac II costs about $6500.

**TO SWITCH OR NOT?** If you already own a Macintosh and are satisfied with your hardware and software, you may find little reason to change anything because of these new models. But realize that your hardware may not be able to accommodate the newest software. If you choose not to upgrade, you will eventually be closed out of new developments, although repairs and replacement parts for all Macintosh models should be readily available for the next few years. Whatever your machine, buy only those accessories that can be used with the new mod-

els—an external modem, for example, rather than internal.

If you have one of the original 128-KB Macintoshes (1984), you should upgrade its random-access memory (RAM) to 512 KB. Many independent companies, as well as Apple, can do this for you. Once the memory is upgraded, your machine will operate exactly like an original Macintosh 512K. Keep it if the capacity, performance, and existing software satisfy your needs. If you need further enhancements, though, it's probably time to trade up to a new machine.

If you have an original Macintosh 512K (1985), the essential accessory is an external disk drive. Used, single-sided floppy-disk drives should be readily available at low cost. If you need a hard-disk drive, however, don't add one; trade in your machine for a newer model instead. If this is impossible, then have a SCSI port adapter installed (pronounced Scahzzy, for small-computer system interface) and get a SCSI hard-disk drive, preferably from the same vendor at a package price. You could also get an Apple HD-20 hard-disk drive that connects through the floppy-disk port. Older hard-disk drives that connect through the serial ports may still be available, but don't buy them unless they are very cheap—under $150—and demonstrably reliable. SCSI connections are designed for fast operation, so a hard disk connected via a SCSI port will perform much better than one installed via either a floppy disk or serial port.

If such an addition meets your needs, you may not have to switch to a more recent model. But the Mac 512K is already a dead end. An increasing number of new software products will not work with its ROM. Although this model can be partially upgraded to incorporate some features of the Mac Plus—like the SCSI hard-disk interface—the various conversions are not really worth the trouble. You are better off selling your Mac 512K (or 128-KB Mac) and getting a newer model.

If you have a Macintosh 512K enhanced (1986)—a hybrid model combining some features of the Mac Plus with the basic layout of the Mac 512K—and need more advanced features, you will do best by getting a newer model. In other words, don't upgrade your 128- or 512-KB machine to a 512K enhanced; sell it instead. Apple built the 512K enhanced because dealers wanted a less expensive product to sell with the Macintosh Plus. Because the 512K enhanced uses the 128-KB ROM, most 1987 software runs on it without difficulty. But it lacks a SCSI port and thus cannot work effectively with a hard-disk drive. This unhappy design was outdated when it was introduced.

If you have a Mac Plus (1986), you should certainly consider getting an external hard-disk drive. Internal-memory upgrades up to four megabytes are also practical. There are many other kinds of internal accessories for the Mac Plus, ranging from hard-disk drives to large display screens, but internal additions are not recommended. In the long run, you will be better off switching to a Macintosh SE or II, which are both designed to accept a variety of internal components. On the other hand, if your work would gain nothing from such modifications, you will not find much advantage in the slightly faster and noisier SE.

In short, if you don't need the latest and fastest hardware or software, and your present microcomputer has enough memory (at least 512 KB), trading up is unnecessary. If, however, you need more speed or more features, or you are shopping for your first Macintosh, buy a Mac SE or Mac II, realizing that power and flexibility come at a price.

**IBM AND MAC CONVERGE.** In many ways Apple and IBM's engineering and marketing strategies are converging—ultimately to the user's benefit. Microcomputing is getting distinctly better. Macintoshes now have slots for accessory boards, as IBM PCs always have. IBM is planning to mold its software interface after the Macintosh pattern. Both companies are targeting their new high-end machines squarely at business users. But it will take several confusing years for IBM software to mature. To see where microcomputing is going in the meantime, get a Macintosh II. Based on a combination of both hardware and software, it is easily the best-designed microcomputer yet. □

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PAUL WESTON

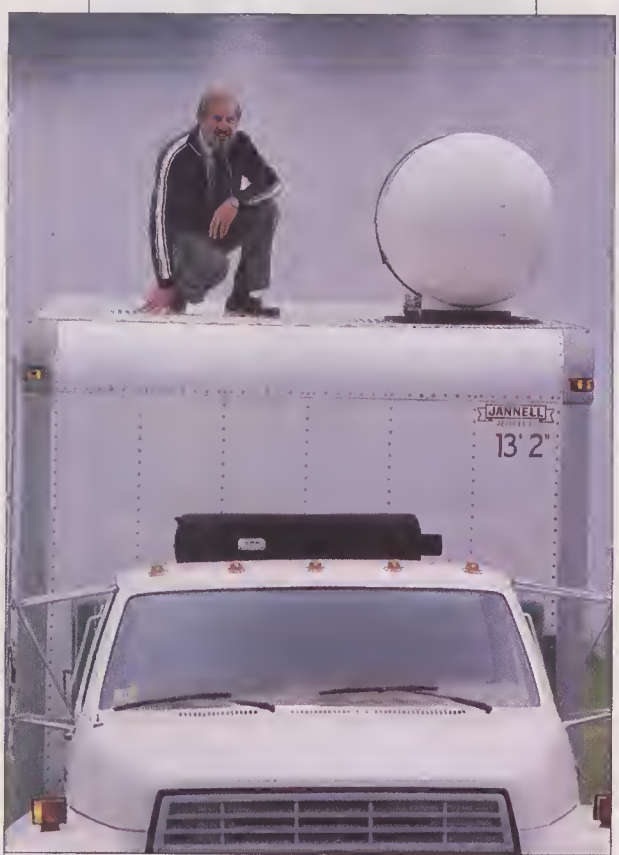
# LASER RADAR COMES OUT OF THE LAB

Ever since the dawn of the laser age, scientists have known that laser beams can be bounced off the air to glean important data about the nature and extent of pollutants. But this technique—known as lidar, for light detection and ranging—has remained mostly a research tool because of the high cost, bulk, and unreliability of early prototypes. Now, aided by a host of government programs, lidar is finally coming into its own for routine environmental monitoring tasks. Laser specialists predict that cheaper, smaller, and more reliable lasers now in the laboratory will lead a flood of new industrial lidar applications in as few as five years.

On the experimental front, lidar has scored successes in gauging wind speeds near airports, measuring the hole in the ozone layer over Antarctica, and tracking the volcanic ash plume from Mount St. Helens. But the technology has also begun to do yeoman duty in a number of other applications.

NASA, for example, is routinely using lidar to track hydrogen fuel vented from its rockets on the launchpad and to warn of explosive concentrations of the gas. Lidars are also being used to calibrate a new generation of advanced radars that will monitor winds at airports continuously and warn of wind shear and other dangerous conditions. Lidars are still too expensive to replace airport radar, even though they are more accurate. On a more ambitious scale, by the mid-nineties, a joint program among NASA, the National Oceanic and Atmospheric Administration, and the European Space Agency will deploy lidars in space to observe global temperatures, water vapor, ozone levels, stratospheric aerosols, and other meteorological variables.

Outside the United States, a lidar system installed at a British Gas plant warns of potentially dangerous levels of flammable methane near a pipeline. And several government-owned power facilities in Ontario, Canada, use lidar to track the plumes of sulfur and nitrogen oxides emitted from smokestacks. Lidar gas monitoring is also commonplace in West Germany and France.




*Computer Genetics president Bernard Caputo perches next to a lidar that detects pollutants from afar.*

Most of these lidars are at government-owned or operated facilities. They are custom-made by a handful of manufacturers, including Computer Genetics (Wakefield, Mass.) and Optech (Toronto). But commercial lidar won't really take off until private industry embraces it in a big way—which is predicted to happen within the coming decade as new lasers permit a dramatic drop in their costs.

"I can see lidar having a clear-cut role in industry," says physicist Dennis K. Killinger of MIT's Lincoln Laboratory (Lexington, Mass.). Its most probable function, he says, will be as "a smart spectroscopic probe of the environment." Such an instrument could detect a wide range of toxic gases with greater sensitivity than can the present fixed-point sensors, which gather air samples only at widely spaced locations and may miss localized clouds of dangerous gases.

Industry is becoming more aware of lidar's value. At chemical companies in particular, the post-Bhopal emphasis on early-warning safety systems has generated interest in lidar and other remote sensing technologies. In fact, such giants as Union Carbide and Monsanto say they are actively studying the possible use of lidar but have no immediate plans to deploy it. Neither company will say why it is holding back. But according to Computer Genetics president Bernard Caputo, "The big hang-up at the chemical companies is the high cost." This ambivalence is understandable. Commercial lidar systems cost $300,000–$500,000 and require a crew of scientists to interpret the results.

Things should change, however, when the new low-cost, high-efficiency lasers are perfected by the early nineties. These solid-state lasers will allow hand-held lidar systems costing $10,000 or less, according to Lincoln Lab's Killinger. While such units won't have the versatility or miles-wide range of their costlier cousins in use today, they will be more than adequate for routine monitoring of gases and toxic chemicals. Moreover, Killinger predicts, these compact lidar systems will find a home in industrial process control, a potentially lucrative sector that has so far turned a cold shoulder to lidar because of its high cost.

Today's lidars are a collection of several distinct but related remote sensing systems that can be deployed from the

**by Gordon Graff**

SETH RESNICK

ground, from aircraft, or from space. They all consist of a laser, optics to focus the feeble return signals, light detectors, and computer and graphics systems to analyze and display the data. A number of nonlaser remote sensing systems exist as well. They are based on emission and detection of backscattered infrared and ultraviolet light or on passive detection of reflected radiation from the ground or air. The nonlaser systems are generally less costly, but also less accurate than lidar.

In the most widely used form of lidar, a transmitted laser beam is scattered and reflected by dust, smoke, fog, or other airborne particles. A photodetector near the laser measures the intensity of the reflected light. The stronger the return signal, the more particles are present.

Another technique, called differential-absorption lidar (DIAL), uses two laser beams—one at a wavelength known to be absorbed by the molecules under study, the other at a wavelength not absorbed. The returned radiation is analyzed. The greater the difference in strength between the two returned signals, the greater the amount of the particular molecules in the atmosphere. DIAL can detect water vapor, ozone, sulfur dioxide, nitrogen oxides, methane and ethane, ammonia, hydrogen chloride, carbon monoxide, and carbon dioxide.

Other variations of lidar have found more specialized application. Fluorescence lidar, for example, can measure the atmospheric concentration of hydroxyl radicals, a chemical species that has been linked to the breakdown of the ozone layer. In this method, the laser beam is tuned to the wavelength absorbed by the hydroxyl, which responds by emitting light. The amount of fluorescent light a photosensor detects tells how much hydroxyl is in the air.

Closely related is Raman lidar. Here, laser light absorbed by atmospheric gases is shifted toward the red region of the spectrum and reradiated. The degree of this red shift depends on temperature, allowing the lidar to serve as a remote thermometer. Another technique, Doppler lidar, measures wind speeds by the tiny, but detectable, shifts in the frequencies of the laser light returned from airborne particles.

The various sources of laser light now employed in lidar have their pluses and minuses. The YAG crystal laser, used in atmospheric backscatter and DIAL systems, can be tuned to different frequencies, but only to several discrete spectral lines. The same is true of carbon-dioxide lasers, a component in DIAL and Doppler units. Even better, however, would be a laser that could be tuned continuously, allowing it to zero in on any of a wide range of molecules. The dye lasers used in DIAL, Raman, and fluorescence units are able to do this, but only over a narrow range of frequencies.

In any case, carbon-dioxide and dye lasers are not suitable for space deployment, notes Richard R. Nelms, head of the advanced sensors program office at NASA's Langley (Va.) Research Center. Not only are they too heavy, he explains, but "they wouldn't survive the extreme temperatures and mechanical shocks of the launch." Nor could they last several years without maintenance. Added to the problems of size, weight, inability to be tuned, limited spectral range, and unreliability is cost. The laser alone often runs around $50,000. And for maximum versatility, a lidar system may consist of three, four, or even five lasers.

**The post-Bhopal chemical industry is looking hard at lidar for early detection of dangerous gases. New, less costly lasers should hasten deployment by such companies as Union Carbide and Monsanto.**

New lasers under development may ultimately cost a tenth as much as those used in lidar now, according to Lincoln Lab's Killinger. Schwartz Electro-Optics (Orlando, Fla.), for example, is looking at one promising new laser that consists of a magnesium-fluoride crystal with some cobalt added. Although this laser has to be cooled slightly below room temperature to work properly, vice-president Peter Moulton says he has designed an electrical minicooling apparatus with no moving parts that does the job efficiently. Lidar systems based on this laser, Moulton adds, could be used for quality control when the amount of a particular molecule is crucial to a process. Schwartz Electro-Optics is also developing a sapphire laser durable enough to operate untended in a satellite for five years, an effort sponsored by NASA.

Other companies are active as well. Spectra-Physics's Laser Analytics Division (Bedford, Mass.) is exploring new ways to fabricate tiny but powerful semiconductor lasers to energize the crystal lasers used in advanced lidars. Arrays of these diodes could replace the comparatively bulky and delicate flash lamps now used. At Allied-Signal's research labs (Morristown, N.J.), the alexandrite laser—a crystal composed of beryllium, aluminum, and oxygen, doped with small amounts of chromium—is emerging as an important candidate for military and government lidar systems, according to Michael L. Shand, manager of the company's laser research and development.

The alexandrite laser, which Allied-Signal has tried with little success to sell to private industry for almost a decade, must be pumped by a flash lamp. But, Shand says, it is compact, powerful, rugged, and continuously tunable over a fairly broad range of wavelengths. Therefore, he notes, officials at both NASA and the Strategic Defense Initiative program are looking at it as a satellite-borne tool for remote sensing. In the SDI application, the alexandrite laser would assess atmospheric conditions before ground-based lasers fired their beams at attacking missiles.

The imminent arrival of these slimmer, trimmer, and cheaper lidar lasers does not mean that today's elephantine truck-mounted lidar units are headed for the scrap heap. But, concedes Bill Matvichuk, marketing manager at Optech, "there won't exactly be a mass market for them." Larger lidars, with their advantages of versatility and wide range, will continue to be made on a custom basis, chiefly for government-sponsored projects, Matvichuk figures. But the small production quantities will keep prices high, keeping away private-sector customers who might otherwise be interested in purchasing them.

The real breakthrough in lidar will come with the arrival of the miniature, low-cost new lasers now being developed. Not all the new lidar units based on these lasers will send their light beams through the air, says Lincoln Lab's Killinger. Many will employ optical fibers that snake their way throughout a plant, he predicts. That way, one modest-sized lidar could effectively monitor a whole facility. "Regardless of how the signals are propagated," Killinger says, "there's a tremendous amount of opportunity for lidar out there in industry." □

*Gordon Graff is a frequent contributor to* HIGH TECHNOLOGY.

# INTERACTIVE TV OPENS NEW RETAIL MARKET

If tests now under way prove successful, two interactive-television technologies may add a significant new twist to U.S. retailing. The systems—J. C. Penney's Telaction and Symonds Associates' TV Answer System—provide instantaneous two-way communication between viewers and a central computer that downloads video signals to home televisions.

Practical interactive television has long been a dream of retailers such as Penney and Sears, which want to offer shoppers the convenience of ordering merchandise at home with the touch of a button. Other businesses want to offer services such as pay-per-view TV and television on demand, which allows a viewer to order a movie or TV show from a video catalog.

Earlier attempts at interactive television have failed to efficiently handle millions of people interacting with a central control point. Attempts to use cable failed because few cable systems are capable of two-way communications. Operator-based telephone systems have proved expensive, clumsy, and easily overloaded.

Telaction's solution is to wed telephone and cable in an interactive service that users control with ordinary Touch-Tone telephones. Codeveloped by Penney (Chicago)—which has so far invested half of its $40-million budget—and Penney-controlled Cableshare (London, Ont.), Telaction will be tested in more than 125,000 Chicago-area homes beginning in September. If the test is successful, the Penney subsidiary Telaction Corp. (Schaumburg, Ill.) plans to establish regional "electronic malls" nationwide.

The system will require local cable-television networks to dedicate a channel for Telaction. With the channel tuned in, a viewer will telephone a local number and punch in an identification code, which accesses the control computer. Selecting from menus on the television, a user will register choices on the telephone keypad. The selected image—perhaps an item offered for sale in the system's electronic catalog—will appear as a still picture with background sound and narration.

At the receiving end, the requests will be filled by Tandem computers controlling the system, which will package the appropriate images—stored on laser disks—for electronic transmission. The signal will then be sent to the customer's cable system via microwave transmission, terrestrial lines, satellite, or other existing data-communication network. The cable system will automatically route the signal to a decoder located on a utility pole near the viewer's home. In the Chicago test, 8–12 homes will share a single decoder in party-line fashion, with only one viewer able to use the system at a time. The decoder will convert the signal for television and pipe it into the user's home. Telaction Corp. expects this selection process to take only a second or two.

As it's being set up by Penney, Telaction will be a wide-scale retail service that gives viewers access to electronic "shops" run by approximately 50 national and local merchants, including Penney, Marshall Field's, Spiegel, wholesale grocer Nash Finch, Ticketron, and Foot locker. Therefore, Telaction will not threaten established retailers—rather, it gives them another way to peddle their wares.

Telaction president Stuart MacIntire predicts that consumers will flock to Telaction because it provides extra convenience at no extra price—the channel will be free to cable subscribers, and with decoders located outside the house, there will be no need for special equipment. Telaction will be available nearly 24 hours a day, seven days a week. Users will be able to charge purchases with the touch of a button and specify when and where to have it delivered.

While it will offer shoppers more convenience, Telaction will give merchants greater flexibility. It will be an economic way to sell in far-reaching geographic areas, shipping out of a central warehouse rather than stocking many separate stores. As the population shifts, electronic stores will be able to move with consumers at minimal expense. Further, Telaction will regularly provide computer-generated reports indicating merchandise sold, plus the demographic profile of the shoppers—valuable marketing information that is often hard to obtain.

Pictures and sound will be stored on laser disk and thus will be relatively hard to change. However, new disks will be supplied regularly, and the merchandise presentation can be altered by simple programming changes. For example, merchants may select which image appears first on the screen when a shopper accesses the store, perhaps displaying a picture of merchandise on sale. Also, alphanumeric information, such as prices, can be stored on computer and superimposed on pictures when they are sent to the viewer. This will allow merchants to change prices at any time.

Telaction is the result of four years of market research and technical development by Penney. Telaction Corp. expects to get the majority of its revenues from fees that other retailers pay to be a part of the service. Charges to cable operators who carry Telaction will be low, ensuring that the channel will be provided to their customers at no extra charge. MacIntire points out that Telaction will be an extra service to help cable operators sell and retain subscribers.

**"There are 44 million cable subscribers today; we are selling to a mass audience, not a niche with PCs in their homes."**

*Wayne A. Miller, Telaction vice-president*

The TV Answer System—the second current contestant in interactive TV—takes an entirely different approach. Unlike Telaction, Answer System hasn't yet established any applications. It is now undergoing technical trials in Washington,

**by G. Berton Latamore**


ANDREA BARUFFI

D.C., which are scheduled to continue into next year. Initial applications are expected to include spot quizzes for televised learning, pay-per-view, polling, and TV marketing. The Answer System promises a less expensive alternative to current approaches to such markets. For example, present pay-per-view services depend on human telephone operators who receive and process orders for shows. In addition to being expensive and labor-intensive, these systems can be easily overloaded. A flood of orders may come in 15 minutes before the start of a popular show, such as a major sports event. At such peaks operators tend to make mistakes, and many potential customers can't get through on the crowded phone lines.

The Answer System will also take a different technological approach. Invented by Oscar Morales-Garza of Mexico and developed by Symonds Associates (Washington, D.C.), it will use low-power radio-broadcast units to connect home televisions with local receiving stations. Viewers will respond to one-line questions appearing at the bottom of TV screens, and the stations will collect their responses. The Answer System will be able to handle as many as one million responses per minute at each collection site, president Steven Symonds claims.

The Answer System will require a small decoder-transmitter—expected to cost about $100 to produce—that will be rented to subscribers. It can be used with any standard TV distribution method, including broadcast, satellite, and cable. The system will be much less expensive to provide than Telaction. Instead of complex equipment, such as voice-synthesis units and banks of videodisk players, the TV Answer System will use a standard IBM PC/AT and a video-signal inserter.

Messages will be inserted into regular

**"With its million responses a minute, TV Answer System is elegantly simple and versatile over a wide range of applications."**

*Steven Symonds, president, Symonds Associates*

## HOME VIDEOTEX CHALLENGED BY INTERACTIVE TV

An altogether different approach to electronic, at-home shopping is being taken by Trintex (White Plains, N.Y.), a joint venture between IBM and Sears. In January the company plans to start a national home videotex service that differs from interactive television in many important respects.

Trintex is a computer communications service, requiring users to own a personal computer, a 1200-baud modem, and special communications software. Although a formal announcement has not been made, Harry E. Smith, vice-president of product and commercial development at Trintex, has implied that the new IBM Personal System/2 family will be required for the service. Because it uses a computer monitor, Trintex will not be able to provide the television-quality pictures that Telaction hopes will tempt its shoppers to buy.

But Trintex is more than a home shopping system. It will offer a variety of services, such as customized news summaries, airline reservations, financial transactions, electronic mail, and games. Because of this diversity, Trintex is expected to be more challenging to operate than interactive television, such as Telaction, which is tightly focused on home retailing.

Also unlike Telaction, Trintex will probably charge a yet-to-be-announced subscription fee. It is generally presumed that users will be assessed either a sign-up fee, monthly service charge, per-minute usage charge, or a combination of these.

Videotex services have been tried before in the United States and overseas, but they have not yet proved popular with the general public. By far the most successful is CompuServe (Columbus, Ohio), a text-only service that can be accessed with any PC and a modem of any speed, or with virtually any communicating terminal. Still, CompuServe has fewer than 500,000 subscribers—enough to make the system profitable, but too few to qualify as a mass medium.

Consequently, many industry observers dismiss Trintex as an outmoded idea that has little chance of success. A recent issue of *VideoPrint,* a leading videotex industry newsletter published by International Resource Development (Norwalk, Conn.), captured the prevailing sentiment: "Expensive terminals, heavy use of graphics, too many offerings, little market definition, and selling into no one market in particular all add up to a service no one has shown much inclination to pay for. . . ." —***G. B. L.***

television signals in a way that will not interfere with TV reception. However, the decoder will capture the message—for example, in a pay-per-view application, "Do you want to see tonight's fight?"—and display it inconspicuously at the bottom of the TV screen. Viewers respond through the television's remote controller, sending a signal that's captured by the decoder and broadcast back to the control computer with a built-in 20-watt transmitter.

The Answer System may also play a key role in the development of TV-on-demand systems. These services, which are expected to appear in the early nineties, will allow viewers to order a program or movie from a central video library. The order will be broadcast to the subscriber's home at a time specified by the subscriber. A technique like Answer System will permit suppliers to economically handle the large number of orders that view-on-demand systems need to be profitable.

Telaction and the Answer System may not be the only interactive-television technologies on the horizon. Since the Telaction announcement, the TV industry has been ripe with rumors that a large corporation is close to announcing its own interactive-TV solution (see "Home Videotex Challenged by Interactive TV").

**"Our market will be the significant number of people who have computers and want the convenience of electronic services."**

*Bruce E. Bellmare, Trintex director of financial services marketing*

Not everyone is optimistic about the future of interactive TV, particularly in retail sales. Steven B. Weissman, vice-president for market intelligence of Communications Publishing Group (Natick, Mass.), questions whether the present fad in home shopping will stand the test of time. "I have three cable shopping channels right now, and they pale rapidly." Admitting that these current services are less convenient than Telaction, Weissman still questions whether many people will use the service. "In any case, they will have to aggressively promote it to get people to notice it among all the new channels that cable systems offer," he says.

Weissman considers the Answer System a more promising alternative. "It can solve a major problem in pay-per-view," he says. "And I'm intrigued by the educational application—particularly for children's shows such as 'Sesame Street.' I think the Answer System could be a natural success." □

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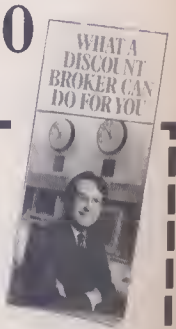


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**MS-DOS Manager.** Software interface that substitutes for MS-DOS command line processor so both applications programs and MS-DOS can be run. Available with Zenith's eaZy PC. Microsoft, P.O. Box 97017, Redmond, WA 98073–9717, (206) 882–8080. Circle 222.

**MS OS/2 Software Development Kit.** Aids in beginning work for moving applications software to 80286- and 80386-based PCs. $3000 (includes training). Microsoft, P.O. Box 97017, Redmond, WA 98073–9717, (206) 882–8080. Circle 223.

**SuperChart.** Generates high-quality charts from spreadsheets. $395. Computer Associates International, 1 Tech Dr., Andover, MA 01810–2497, (617) 685–1400. Circle 224.

**Windows GRAPH.** Creates charts and graphs from data files. Full 3-D support. For Windows users. Supports dynamic data exchange. $395. Micrografix, 1820 N. Greenville Ave., Richardson, TX 75081, (800) 272–3729. Circle 225.

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**PageLaser12.** Prints 12 pages per minute. Designed for shared printers with high paper volume. $3699. Toshiba America, Information Systems Div., 9740 Irvine Blvd., Irvine, CA 92718, (714) 380–3000. Circle 228.

**Page Reader.** Reads documents into PCs. $1299. Saba Technologies, 9300 S.W. Gemini Dr., Beaverton, OR 97005, (800) 654–5274. Circle 229.

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## SHOP BY THE NUMBERS

To receive more information on the products or services in this issue, circle the Reader Service number which corresponds to the number on the item in which you are interested.

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- ☐ A. Manufacturing
- ☐ B. Retail/Wholesale
- ☐ C. Financial Services
- ☐ D. Business/Professional Services
- ☐ E. Electrical Equipment
- ☐ F. Machinery
- ☐ G. Computers Software
- ☐ H. Other_____

**2) Title**
- ☐ 1. Owner/Partner
- ☐ 2. Chairman/President
- ☐ 3. Vice-President
- ☐ 4. Treasurer
- ☐ 5. General Manager
- ☐ 6. Other_____

**3) Purchasing Authority**
- ☐ A. Recommend
- ☐ B. Specify
- ☐ C. Approve

**4) Number of Employees**
- ☐ 1. Less than 20
- ☐ 2. 20-99
- ☐ 3. 100-499
- ☐ 4. 500-999
- ☐ 5. 1000+

**5) Annual Dollar Volume**
- ☐ A. Under $500,000
- ☐ B. $500,000 – $4.9 million
- ☐ C. $5 – $24.9 million
- ☐ D. $25 – $74.9 million
- ☐ E. $75 million+

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August, 1987

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C cassette. 1.7 lbs. Under $1000. Zenith Electronics, 1000 Milwaukee Ave., Glenview, IL 60025, (312) 391–7000. Circle 236.

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**X-AMP.** Isolates and bypasses car battery to accurately control ancillary 12-24 volt DC. Price varies. Brevac International, P.O. Box 180, Berkhamsted, Herefordshire HP4 1EP UK, 4427–72959. Circle 239.

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**Green Light Microlaser.** Replaces traditional gas discharge lasers. Useful for industrial holography. Provides precision analysis of mechanical components. Takes inventory with hand-held scanners. Available in September. Amoco Laser, 1809 Mill St., Naperville, IL 60540, (312) 369–4190. Circle 240.

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**RTX Personal Robot.** Performs hundreds of tasks in health care, laboratory research, education, and light industry. 62 lbs., 4'. Lifts more than 8 lbs. $12,000. UMI, 2727 2nd Ave., Suite 159, Detroit, MI 48201, (313) 963–5450. Circle 246.

**Direct Drive Servo Actuators and Motors.** With high torque and low speed, has accuracy of ±30 arc-seconds, with repeatability of ±2 arc-seconds and positioning resolution of more than 650,000 pulses per resolution for robotics. Requires no gears or other speed reducers and no lubrication. From $4000. Yokogawa Electric, c/o Tech Tran Consultants, P.O. Box 206, Lake Geneva, WI 53147. (414) 248–4650. Circle 247.

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**Daytracker I.** Cuts daytime lighting costs up to 90%. Operates independently of any external power source or electronic-control system. Price varies. International Daytracking Systems, 4909 Pacific Hwy., San Diego, CA 92110, (610) 260–1860. Circle 249.

**Solid State Photomultiplier.** Has both defense and science applications, including astronomical observations and long-wavelength spectrometry. Fits on infrared telescope. Observes particle nature of infrared and visible

$3500. Lightsense, 1513 18th St., Santa Monica, CA 90404, (213) 828–1045. Circle 252.

**Miniature Optical Bench.** Moves lenses that must be held. Has 26mm compact profile, X26 rail foundation, with rails up to 0.5 meters long. Includes 4 parallel working tempered-stainless-steel working surfaces. Basic rail price: $80. Klinger Scientific, 110–20 Jamaica Ave., Richmond Hill, NY 11418, (718) 846–3700. Circle 253.

**Encoder Kit.** Senses motion of machine-tool moving parts. Features integrated optoelectronic technology. Available in resolutions of 60, 125, 150, 192, 200, and 250 pulses per revolution. $19.18 in 250-piece quantities. Honeywell, Disc Instruments Subs., 102 E. Baker St., Costa Mesa, CA 92626, (714) 979–5300. Circle 254.

**Lure Capsules.** Multifill capsule pest-control system: outer capsule lures male insects away from females, and inner contains poison. $0.65 per lb., in 1-million-lb. units. Insulated Technologies, P.O. Box 66, Darby, PA 19023, (215) 461–1711. Circle 255.

**2-Gallon Disposal Can (Model 14724).** Stores waste chemicals. Gauge pops up when container is three-quarters full. High-density polyethylene. $115. Justrite Manufacturing, 2454 Dempster St., Des Plaines, IL 60016, (312) 298–9250. Circle 256.

**High-Flow Polycarbonate Resin.** Useful for packing, processing, preparing, treating, transporting, or holding food. Permits coextrusion and coinjection with temperature-sensitive barrier polymers. Mobay, Mobay Rd., Pittsburgh, PA 15205, (412) 777–2496. Circle 257.

**3-Channel Digital Voice Announcer (Model DVA-1003).** Delivers 3 distinctly different messages from 1–32 seconds, with immediate message reset. Built for high volume duty applications. $990. Viking Electronics, 1531 Industrial St., P.O. 362, Hudson, WI 54016, (715) 386–8861. Circle 258.

memory to PS/2 Model 30, XT, XT 286, or AT. Has 1 serial and 1 parallel port, with option for 2nd serial port. $1145. Intel, 5200 N.E. Elam Pkwy., Hillsboro, OR 97124–6497, (800) 538–3373. Circle 200.

**Spectroscopy Computers.** XT- or AT-based DM3000 series of computers that fully automate spectrometric experiments. Can be purchased with SPEX instrument system. SPEX Industries, 3880 Park Ave., Edison, NJ 08820, (201) 549–7144. Circle 201.

**9600-Baud Modem.** $1195. FASTCOMM Data, 12347-E Sunrise Valley Dr., Reston, VA 22091, (703) 620–3900. Circle 202.

**Desktop Publishing Interface.** IB-1000 board connects PC/AT to Canon NP9030 laser printer. Optical Recording, 141 John St., Toronto, Ont., Canada M5V 2E4, (416) 596–6862. Circle 203.

**Internal Fax.** Half-card board that adds fax capability to a PC. $395. Asher Technologies, 1009-I Mansell Rd., Roswell, GA 30076, (404) 993–4590. Circle 204.

**Laser Beam Printer.** With 512K memory, prints 8 pages per minute. LBP-8II increases font flexibility and paper-handling capability. $2500. Canon USA, 1 Canon Plaza, Lake Success, NY 11042, (212) 688–1200. Circle 205.

**Matrix Processor.** Series of 4 supercomputers that integrate into the DEC VAX/VMS operating system. $1.4 million–$4 million. Saxpy Computer, 255 San Geronimo Way, Sunnyvale, CA 94086, (408) 732–6700. Circle 206.

**PC Compatible.** 80286-based with monitor, integrated software, and monochrome/graphics card. $1995. Delta Computer, 260 Forbes Blvd., Mansfield, MA 02048, (617) 339–5575. Circle 207.

**Auto-Dialer.** Reads telephone numbers from terminal screens and dials them. $1250. Tuck Electronics, 330 2nd St., New Cumberland, PA 11100 W. 82nd St., Overland Park, KS 66214, (913) 492–6002. Circle 212.

**Graphics Workstation.** Has 8-MB RAM and 19" screen. $30,000. Systems Integrators, P.O. Box 13626, Sacramento, CA 95853, (916) 929–9481. Circle 213.

**Spartan 40 SCSI.** Provides 40MB of storage on 2 3.5" disks. Data accesses time cut in half. $225. Lapine Technology, 182 Topaz St., Milpitas, CA 95035, (408) 262–7077. Circle 214.

**80386-Based PC.** Static RAM. DOS-compatible. Has CAD, CAM, and CAE applications. $4,499–$6,499 (depending on options). PCs Ltd., 1611 Headway Cir., Bldg. 3, Austin, TX 78754, (800) 426–5150. Circle 215.

**Multiuser System.** Up to 64 users. 80386-based. Compatible with Altos 80286-based systems. $25,000–$30,000. Altos Computer Systems, 2641 Orchard Pkwy., San Jose, CA 95134, (408) 946–6700. Circle 216.

**Multiuser System.** Up to 8 users. Uses microcomputers on VME bus architecture, with up to 4MB of memory. $7,000–$11,000 (depending on options). Motorola Microcomputer Division, P.O. Box 20912, Phoenix, AZ 85036, (800) 521–6274. Circle 217.

**Array Processor.** Designed for Sun Microsystems workstations. Executes up to 15 million operations per second. $11,900. SKY Computers, Foot of John St., Lowell, MA 01852, (617) 454–6200. Circle 218.

## COMPUTER SOFTWARE

**List Manager.** Prints labels and form letters with duplicate checker. $595. Capstone, 1854 E. Krista Way, Tempe, AZ 85284, (602) 820–7002. Circle 219.

**Data-Transfer Utility.** Integrates Design Dimensions and AutoCAD DXF files for Macintoshes. $495. Visual Information, 16309 Doublegrove, La Puente, CA 91744, (818) 918–8834. Circle 220.

**SuperChart.** Generates high-quality charts from spreadsheets. $395. Computer Associates International, 1 Tech Dr., Andover, MA 01810–2497, (617) 685–1400. Circle 224.

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**Loudspeaker.** Wide stereo imaging with extremely low distortion. $1000 per pair. Altec

Lansing Consumer Products, Rtes. 6 & 209, Milford, PA 18337, (800) 258–3288. Circle 232.

**Weatherproof Speaker System.** Transient response and wide stereo imaging with low distortion. $250 per pair. Altec Lansing Consumer Products, Rtes. 6 & 209, Milford, PA 18337, (800) 258–3288. Circle 233.

**Pulling Gs.** 60-minute digital audio-video jet-pilot simulation on 12" laser disk. $39.95. Optical Data, P.O. Box 97, Florham Park, NJ 07932, (201) 377–0302. Circle 234.

**Programmable Scanner.** Search weather scan, priority channel, 30 channels, and 6 UHF and VHF ranges. $199. Regency Electronics, 7707 Records St., Indianapolis, IN 46226, (317) 545–4281. Circle 235.

**Camcorder.** Records up to 60 minutes on VHS-C cassette. 1.7 lbs. Under $1000. Zenith Electronics, 1000 Milwaukee Ave., Glenview, IL 60025, (312) 391–7000. Circle 236.

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**Nitrogen Laser.** Serves as light source for fluorescent studies. Marks and cuts semiconductor materials. Useful in particle-physics and biomedical investigations. $4900. Laser Science, 80 Prospect St., Cambridge, MA 02139, (617) 868–4350. Circle 242.

**Oil-Free Mechanical Vacuum Pump.** Rough-pumps clean-vacuum systems that cannot tolerate hydrocarbon contamination. Used for semiconductor processing and high-energy physics research. Varian Vacuum, 121 Hartwell Ave., Lexington, MA 02173, (617) 861–7200. Circle 243.

**Thermocouple Gauge Controller.** Measures pressure and controls load-lock valves in semiconductor processing equipment. Varian Vacuum, 121 Hartwell Ave., Lexington, MA 02173, (617) 861–7200. Circle 244.

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**Solid State Photomultiplier.** Has both defense and science applications, including astronomical observations and long-wavelength spectrometry. Fits on infrared telescope. Observes particle nature of infrared and visible radiation. Detects single photons and continuously counts photons. Not sold as single component. Rockwell International, 1049 Camino Dos Rios, Thousand Oaks, CA 91360, (805) 373–4104. Circle 250.

**Electroluminescent Indicator Lamp.** Can be changed without turning off power, and bulb lasts 10 times longer than traditional LED lights, thus trimming operating costs. Price varies. French Technology Press Office, 401 N. Michigan Ave., Suite 601, Chicago, IL 60611, (312) 222–1235. Circle 251.

**Fiber-Optic Colorimetry System.** Designed for field and lab color-solution measurement and monitoring chemistry. Features microliter sample size. Lightweight, battery-operated. Provides spectral and fluorimetric measurements up to 18 hours per charge. $3500. Lightsense, 1513 18th St., Santa Monica, CA 90404, (213) 828–1045. Circle 252.

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## JOINT VENTURES

***The following companies have agreed recently to undertake joint projects:***

**Fairleigh Dickinson Laboratories and Kronus Market Development.** To market a complete product line and to produce rapid lab screening tests for herpes and allergies. Fairleigh Dickinson Laboratories, 1249 Ambler Ave., Abilene, TX 79601, (915) 677–1386.

**Corporation for Open Systems International and National Computing Centre.** To develop a protocol tester for file-transfer access and management and message-handling systems. The tester will be available under license from COS, which will also operate a testing service. Corporation for Open Systems, 1750 Old Meadow Rd., Suite 400, McLean, VA 22102–4306, (703) 883–2700.

**Banyan Systems and Northern Telecom.** To resell Banyan's networking software (VINES) and high-performance servers as part of the Northern Telecom Meridian LANSTAR PC product offering and to develop software modules and drivers to support the LANSTAR PC network. Banyan Systems, 115 Flanders Rd., Westboro, MA 01581, (617) 898–1000.

**Lotus and Telerate.** To develop and market financial-services products. The products provide domestic and international traders with Lotus 1-2-3 access to Telerate real-time credit-market data. Lotus, 55 Cambridge Pkwy., Cambridge, MA 02142, (617) 577–8500.

**International Data Corp. and Seybold Group.** To provide consulting services as part of an IDC Partner program to IDC's vendor and information-systems user clients in microcomputer communications. International Data Corp., 5 Speen St., P.O. Box 915, Framingham, MA 01701. (617) 872–8200.

**Cullinet Software and Fujitsu.** To support and market Cullinet's IDMS/R (Integrated Database Management System/Relation) and related applications on the FACOM-M series of computers under the MSP operating system. Cullinet Software, 400 Blue Hill Dr., Westwood, MA 02090, (617) 329–7700.

**Fifth Generation Systems and Touchstone Software.** To do several computer-oriented projects, currently under way, and to enhance marketing for both companies. Fifth Generation Systems, 11200 Industriplex Blvd., Baton Rouge, LA 70809, (504) 291–7221.

**Pesch and CSK.** To develop and market LaserCard–based medical-management systems, which consist of an optical memory device, a read-write unit, and software that will operate on an IBM-compatible PC. Pesch, 12 Greenway Plaza, Suite 1400, Houston, TX 77046, (713) 621–5688.

**Ecogen and Monsanto.** To develop proprietary genes that control protein production. These genes will act as ingrown pesticides in plants. Ecogen, 2005 Cabot Blvd. W., Langhorne, PA 10947, (215) 757–1590.

**University Science Partners and Michigan State University.** To experiment with improvements for polymers, metals, ceramics, materials processing, and materials evalution. MSU is not required under the agreement to offer any projects for funding. University Science Partners, 321 Fisher Bldg., Detroit, MI 48202, (313) 873–7800.

**Fortune Systems and Data Language.** To run PROGRESS, Data Language's software, on Fortune Systems's hardware, a transaction-processing-based fourth-generation language and relational data-base-management system to the Fortune Formula series, FS's line of supercomputers. Fortune Systems, 300 Harbour Blvd., Belmont, CA 94002, (415) 593–9000.

**SmithKline Beckman and Boehringer Mannheim GmbH.** To develop and market cardiovascular medicines discovered by Boehringer Mannheim. SmithKline Beckman, One Franklin Plaza, P.O. Box 7929, Philadelphia, PA 19101, (215) 751–4000.

## CONTRACTS

***Contracts were awarded recently to the following companies:***

**Autometric from Rome Air Development Center.** $10 million. To continue providing direct R&D engineering support, as it has done since 1982.

**McDonnell Douglas from the Air Force.** $9.9 million. To develop an additional refueling system for the KC-10 advanced tanker-cargo aircraft. The new system will consist of two hose-drogue refuelers.

**Battelle from Illinois Dept. of Nuclear Safety.** $8 million plus. To give technical assistance in selecting among eight sites for disposal of low-level nuclear waste.

**Rockwell International Collins Defense Communications from the Air Force.** $4.7 million. To produce 10 AN/TSC-60(V)9 Communications Centrals to replace the AN/TSC-60(V)1s produced by Rockwell in the early seventies. The AN/TSC-60(V)9 is a sheltered system that provides short-, medium-, and long-range high-frequency communications for the Air Force Tactical Air Control System.

**Apollo from Mentor Graphics.** $100 million. To purchase a range of Apollo products, including Domain Series 3000 Personal Workstations and DN570 TURBO graphic workstations, to serve as a hardware platform for Mentor Graphics' IDEA Series of Engineering Workstations used by technical professionals.

**LTV Aircraft Products Group from Canadair.** $10 million. To continue production of nacelles (engine covers) and thrust reversers for the Challenger 601-3A executive business jet.

**Stantel Telecommunications from British Telecom.** $60 million. To improve communications in London. When Phase 2 of the new City Fiber Network is in place by mid-1988, the connection time for a new telephone-data link will be reduced from days or sometimes weeks to a few seconds.

# Get The Edge . . .

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# FRANCE PLAYS CATCH-UP IN BIOTECH MARKET

After five years of hemming, hawing, and harrumphing, France is out to shed its image as an also-ran in the biotech marketplace. Although the nation faces some tough hurdles in catching up, several recent stirrings in public policy—and more notably new commercial and venture-capital programs in the private sector—suggest that the French are far from out of the race.

The perception of France as an underdog isn't a new one. Other than a few "isolated centers of excellence"—the prestigious Institut Pasteur in Paris, for example, and a handful of French chemical companies—France lacks the "critical mass of qualified personnel" with biotech skills needed to make the leap from laboratory to marketplace, the Office of Technology Assessment (OTA) noted in its landmark 1984 review of international biotechnology. The result: France trails not only the United States and Japan, but also Britain, Switzerland, Holland, and West Germany.

There are several explanations for France's low biotech ratings. One of the most important is rooted in the French culture. "In the United States, nearly every kid over the age of 10 understands the concepts of management and capital," says director J. Paul Richter at Burmah France S.A. (Le Pecq). "That just isn't true here. The French love their music and poetry and literature, but there really isn't much of a business orientation."

Furthermore, in a sense France is a distillation of what has kept Europe from becoming a serious international competitor in technology, especially genetic engineering. Although Britain, Holland, and a few other nations are beginning to break with their ultraconservative traditions, "Europe by and large still lacks an entrepreneurial spirit," says Anne Catherine Jouanneau, Paris-based vice-president of Genex (Gaithersburg, Md.), a leading U.S. biotech company. "So while France has some excellent scientists, they are often incapable of developing a business plan." Along the same lines, she adds, Europe has yet to develop a true venture-capital system: "They don't like to take risks."

A third reason is found in the French government, which has so far given little more than lip service to commercial biotechnology. For example, its 1982 General Research Law promised broad financial support to genetic engineering and other new technologies; it also called for increased collaboration between industry and universities. In the same year a mobilization program proposed by the Ministry of Industry and Research called for specific government interventions in and support for commercial research in new life sciences.

Five years later neither program has delivered on its lofty promises. In fact, funding in several key research areas was slashed during 1982 and 1983 as part of the Mitterand government's austerity drive. "The commitment from the government has been very slow in coming—much slower than in the United States," says Mark Dibner, director of business studies at the North Carolina Biotechnology Center in Research Triangle Park. "A few years ago, for example, the French government allocated 100 million francs for biotechnology, but a lot of that money never got spent." By contrast, the U.S. government has commited $750 million to biotech research this year, mostly through the National Institutes of Health.

During the past year or so, however, French companies have proved much bolder. Such chemical-processing giants as Elf Aquitaine, Rhone Poulenc (which is 100 percent government-owned, but is now attempting to become private), and Roussel Uclaf (40 percent government-owned) have launched several new biotech programs in medical diagnostics, pharmaceuticals, and plant genetics.

Still, those three companies now make up the bulk of the nation's commercial biotech effort. Newer and smaller French companies number only about 25 or so, according to Genex's Jouanneau. What's clearly needed is an influx of new biotech companies that will accomplish what the government cannot or will not do: put biotechnology on the national agenda with the sort of élan that has been demonstrated elsewhere in Europe.

Here and there in France are signs that such a movement may be under way. For example, Molecules Naturelles (Le Pecq) is a one-year-old joint venture between biotech firm Igene (Columbia, Md.) and Biosoph, a division of Britain's $2.5 billion-a-

*Anne Catherine Jouanneau, Paris-based vice-president of U.S. biotech company Genex, says France is hampered by its "lack of entrepreneurial spirit."*

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oriented. Another is that it's relatively small and so can move quickly when necessary. We've had a lot of experience with large organizations and have found that what's lightning speed for them can be agonizingly slow for us."

Also boding well for French biotech is the forming late last year of the nation's first private venture-capital company—called BioInvest—aimed specifically at start-ups in genetic engineering and life

WALTER P. CALAHAN

*Igene chairman Robert Milch in a fermentation lab: helping put France aboard the "second biotech train."*

It's that sense of determination not to be left out again that many observers cite as one of France's biggest assets. "It's true that France missed the first biotech train," Igene's Milch says, referring to the vigorous R&D during the early eighties. "But a second train—the actual commercialization of products—will be coming along within five years. That's the important one, and I think France will be on it." ☐

***—H. Garrett DeYoung***

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*Anne Catherine Jouanneau, Paris-based vice-president of U.S. biotech company Genex, says France is hampered by its "lack of entrepreneurial spirit."*

SADDRI

## How to Take a 10-Year Tax Holiday

The French government has recently announced a system of special enterprise zones similar to those already in effect in Britain, Ireland, Belgium, and elsewhere. This move aims to attract new technologies from the United States and from other European countries—and in the process create more than 1000 new jobs for French workers by 1990.

The program works like this: New French or foreign companies that locate in the regions near Dunkirk in the west and Aubagne-Ciotat in the south—both of which face unemployment rates approaching 14 percent—will be relieved of corporate income taxes for 10 years. All they have to do is begin operations by 1992 and employ 10 or more persons within three years of start-up. The package also includes such incentives as low-cost loans, outright grants, and freedom from red tape. The zones are open to virtually any type of enterprise, except steel, shipbuilding, and other traditional manufacturers.

The program reportedly has already attracted commitments from 23 new companies specializing in food products, sporting goods, microcomputer shells, and other technologies. If successful, the concept could eventually be extended to other regions in France that have been hit by job losses in steel and mining. ***—H. G. D.***

year Burmah Oil. The company is developing new methods for producing natural flavors and fragrances—that is, molecules produced by fermenting Igene's genetically engineered microorganisms rather than by chemical synthesis. Molecules Naturelles is producing one product—isoamyl acetate, which has a strong banana fragrance—at its pilot plant in Rouen. The compound is being marketed by two U.S. companies, and Molecules Naturelles has five other products now under development.

Because these molecules are produced by fermentation, food-processing companies who use them can label their products as "natural," Biosoph's Richter explains. "That's getting to be a big selling point in Europe, and the worldwide market for natural flavors is about $30 million a year." While more costly than chemical methods, the price for them—likely to be $75 or more a pound—will assure profitability, he adds.

Richter is convinced that the collaboration between Biosoph and Igene is not only good business, but could also become a model for other French biotech companies. "In France it often happens that a company has a good product but is unsure of the market or how to sell it," he says. "In this case, Igene had the market and the technical know-how, and we had the money needed for production."

Igene chairman Robert A. Milch is equally enthusiastic about the partnership: "We hooked up with Biosoph for several reasons. One is that it is very product-oriented. Another is that it's relatively small and so can move quickly when necessary. We've had a lot of experience with large organizations and have found that what's lightning speed for them can be agonizingly slow for us."

Also boding well for French biotech is the forming late last year of the nation's first private venture-capital company—called BioInvest—aimed specifically at start-ups in genetic engineering and life sciences. Working with a pool of French banks, BioInvest will offer loans totaling up to $2.5 million during 1987, according to Genex's Jouanneau, currently a consultant to the company. "We don't get involved during the R&D stages," she says. "We're concentrating on companies that can show commercial results within three to five years." Companies need not be French, but they must be located in France. BioInvest has already recapitalized one company: Bioproductions in Perigueux.

BioInvest's role goes beyond simple financing. The company is aggressively seeking out potential new businesses for France, routinely scouring universities, trade shows, and even major companies in a search for innovation. "Many large companies have small programs that are of limited commercial interest to them," Jouanneau explains. "In some cases these projects could be spun off into new small ventures, but the idea of becoming businesspeople is scary to most scientists. We develop their trust and often locate other businesspeople to work with them."

WALTER P. CALAHAN

*Igene chairman Robert Milch in a fermentation lab: helping put France aboard the "second biotech train."*

Yet another role for BioInvest is to minimize the banks' risks by first assessing applicants' technical capabilities, marketing skills, and overall management—a study that typically takes about three months. "We've already turned down applications from three companies," says Jean-Paul Dupuy, director of the Bureau d'Intervention et d'Innovation in Paris, a private consultant specializing in biotech creation and financing that is a BioInvest affiliate. "We can't afford to make any mistakes in this early stage." BioInvest also tries to help the recipient avoid one of the most common mistakes of the successful new company: uncontrolled growth that could seriously strain the firm's capabilities. "The company must have a viable business plan at the outset, then stick to it," Dupuy explains.

No one suggests that these efforts alone will sharpen France's international competitiveness in biotechnology. Compared with most other nations, in fact, they appear almost feeble. But far more important than any single program is the visible enthusiasm for commercial biotechnology not only in France, but in all of Europe. Says Jouanneau: "In electronics, Europe has become little more than a distributor for the United States and Japan. We can't allow the same thing to happen in biotechnology."

It's that sense of determination not to be left out again that many observers cite as one of France's biggest assets. "It's true that France missed the first biotech train," Igene's Milch says, referring to the vigorous R&D during the early eighties. "But a second train—the actual commercialization of products—will be coming along within five years. That's the important one, and I think France will be on it." □ ***—H. Garrett DeYoung***

ENDOGEN:

## Jumping into the Race to Cure Cancer

One of the hottest potential treatments for cancer involves immune-system proteins called lymphokines, which include interleukin-1, interleukin-2, and others. Endogen is investigating ways to detect how much of these substances are already present in a patient's body so that research physicians can determine how much more should be added. Endogen, in collaboration with Genzyme (Boston), has developed the only examination for measuring interleukin-2 in the blood. The test is currently being used in a study by the National Institutes of Health (NIH).

Endogen plans to make the test commercially available to a cancer market that is eager for cures, but the company is awaiting study results. Like its competitors Cetus (Emeryville, Cal.), Ribi (Hamilton, Mont.), Genentech (South San Francisco, Cal.), Hybritech (San Diego), and others, Endogen also produces lymphokines for cancer research.

**Financing:** Founders put up an undisclosed amount to start the company and received a $50,000 Phase I Small Business Innovation Research (SBIR) grant from NIH in 1986.

**Management:** Owen Dempsey (president) was research associate at the International Management Development Institute. Roy A. Dempsey (founder, chairman, and scientific director) was a researcher at the Tufts Cancer Research Center. Phillip Servidori (founder and vice-president of sales and marketing) was medical sales representative for Becton Dickenson.

**Location:** 451 D St., 8th Floor, Boston, MA 02210, (617) 439–3250.

**Founded:** July 1983.

*Shown in their new lab near the World Trade Center (Boston) are Endogen officials Roy A. Dempsey, Owen Dempsey, and Phillip Servidori.*

AION:

## Expert System Manages Other Computers

Aion has introduced an expert system that eases a company's daily administration of data-processing tasks, such as accounting, manufacturing materials and production management, inventory control, sales support, information retrieval and analysis, and expert-system operation. Called the Aion Development System (ADS) and the Aion Execution System (AES), the module requires no special hardware or artificial-intelligence (AI) language, and it runs on existing IBM data-processing systems.

The user can enter commands common to accounting procedures, for example, and the ADS will incorporate them into its knowledge base. The expert system then interprets the contents of this knowledge base and automatically puts together the proper sequence of commands to perform a given task.

Users do not need to be familiar with programming or expert systems. Aion has support staff who help customers design systems.

Companies currently using the system include MSA (Atlanta), Boole & Babbage (Sunnyvale, Cal.), and Provident Life and Accident Insurance Co. (Chattanooga, Tenn.).

**Financing:** $2.9 million venture capital provided by Asset Management, Warburg-Pincus, Brian & Edwards, Glenwood Management, and Girard Capital.

**Management:** Harry C. Reinstein (president and chief executive officer) was AI project technical leader at the Palo Alto Scientific Center of IBM. Lawrence Cohn (senior vice-president of development) was director of design services at Trilogy Systems. Irv H. Lichtenwald (vice-president and chief financial officer) was corporate controller of VisiCorp.

**Location:** 101 University Ave. Palo Alto, CA 94301, (415) 328–9595.

**Founded:** May 1984.

PRIME:

## Finding Homes for Businesses in the Pacific

Access to the Pacific Rim countries—Japan, Korea, Taiwan, China, and Singapore—is particularly difficult for small U.S. companies that may not be able to hire expensive trade consultants. Now a lower-cost alternative is available from Pacific Rim Interface Member Enterprises (PRIME).

For a regular corporate membership fee of $1500 ($1000 for individuals), PRIME clients get discounts on services such as evaluation of products, preparation of technical documentation for business transactions, and translation services, to name a few. What's more, PRIME clients get special access to other members, permitting a single company to draw on the combined international expertise of a broad range of companies. Members include such companies as Adec (Tokyo), Hsing Chang (Taipei), and Unity Capital Corp. (San Diego).

**Financing:** $50,000 from one of the founders, Ichiro Wachi of Tokyo's Interface Inc.

**Management:** Ichiro Wachi (president and cofounder) is also president of Interface. Ramesh Amatya (general manager) is an instructor at the University of Southern California School of Public Administration.

**Location:** 10055 Barnes Canyon Rd., Suite A, San Diego, CA 92121, (619) 453–6047.

**Founded:** November 1986.

DANA SIGALL

VOYAGER:

## Cleaner Clean Rooms Promise Expanding Market

Voyager specializes in the prevention of electrostatic discharge and particle control in clean rooms—a field that's growing more critical as integrated circuits and microelectronics become more sophisticated.

Common activities, such as walking across a carpet, can produce charges up to 35,000 volts. A static charge of only 5–100 volts can jeopordize the production of gallium arsenide chips, according to company sources. Voyager products include room-ionization systems, instruments to measure voltages on people and material, and workbench accessories to provide personnel grounding, connection, or ionization.

**Financing:** $815,997 from 74 shareholders.

**Management:** Peter G. Gould (chairman) was director of strategic planning for the Burroughs Corp. and chairman of its Plasmagraphics joint venture with Telex. Jonathan R. Lax (president) was group vice-president of SL Industries. Peter R. Bossard, (corporate vice-president and head of R&D) was staff scientist at Bell Laboratories. Philip M. Papoojian (vice-president of room-ionization sales and marketing) was business director at Semiconductor Chemicals.

**Location:** 2250 Cabot Boulevard West, Building 40-M, Langhorne, PA 19047, (215) 750–0270.

**Founded:** August 1984.

GTX:

## Cashing in on the Conversion to CAD

For the many companies that plan to switch from engineering drawings to computer-aided design and manufacturing (CAD/CAM)—or already have—a company called GTX offers a system for computerizing old paper drawings. Market potential is enormous. Company officials estimate that there are as many as one billion drawings nationwide. They also say that 40 percent of new drawings are revisions of existing ones.

The new GTX 5000 scans drawings and stores them on floppy disk so they can be revised on a IBM PC/AT. The data can also be converted to the initial graphics exchange specification (IGES) or major CAD formats.

This concept is not new. Companies such as Optagraphics (San Diego), Scantech (Warren, N.J.), and Anatech (Littleton, Colo.) offer similar systems. But GTX claims that its product is the leader in speed and cost, retailing for $70,000, plus another $3900 for editing software. It's the only system that can be used with an IBM PC/AT, the company claims.

**Financing:** $3.5 million from Tokyo Electric Ltd. (Tokyo), $1.5 million direct funding, and another $2 million put up as guarantees for any loans taken out by GTX. Tokyo Electric's was interest purchased by Nippon Steel this year.

**Management:** Marvin T. Ling (founder and president) was founder and president of Graphtek. Mike Cassidy (vice-president of operations) was vice-president of operations for Graphtek. Richard N. Stover (vice-president of marketing) was founder and president of CAD/CAM Advisors.

**Location:** 2501 W. Dunlap, Phoenix, AZ 85021, (602) 870–1696.

**Founded:** March 1985.

STEVEN GOLDBLATT

*Peter R. Bossard (left) and Jonathan R. Lax (right) of Voyager are showing products from their lab that range in price from $95 to $250,000. They estimate that the static-control market is growing 15–20 percent because chips are more sensitive and larger, with up to 400,000 devices on each one.*

LIFE INSURANCE SOFTWARE SYSTEMS OF AMERICA:

## Software Serves Insurance Companies

The National Association of Insurance Commissioners' (NAIC) sample annual statement is a 76-page nightmare for the many insurance companies that must prepare one. Compliance, the first product from Life Insurance Software Systems of America (LISSA), is a computer program specially designed to prepare insurance companies' annual reports. The software is based on the Life Company Annual Statement Handbook.

Compliance, which may be used on an IBM PC/AT or PC/XT, accepts data that is either manually entered or automatically downloaded from another computer system. The software performs 10,000 mathematical computations, cross-references the figures using 1000 reference checks, points out errors and discrepencies, and prints the report in the appropriate format.

Compliance developers feel they have an edge on this market after three states—New Jersey, New York, and Texas—passed laws requiring these NAIC reports be submitted in diskette form.

Since Compliance, LISSA has launched other software products to help companies prepare tax returns and track investments.

**Financing:** $1.2 million self-underwritten and from privately held stock.

**Management:** Michael Zarlengo (chief executive officer and vice-chairman of the board) was tax manager for Arthur Andersen & Co. and Berman & Berman. Joseph Proventure (director of operations) was manager of computer operations for the Institute of Economic Technology. Charles M. Beardsley (chairman of the board of directors) is chief executive officer of Booke & Co.

**Location:** 4200 Commerce Court, Lisle, IL 60532, (312) 357–2410.

**Founded:** November 1983.

ESSAY

# RESEARCH: A NEW AGENDA

BY PHILLIP A. GRIFFITHS
PROVOST, DUKE UNIVERSITY

Since at least World War II the United States has depended on technological superiority to maintain its preeminent military and economic position. Today, however, our technological lead over the rest of the world has narrowed. In some fields it has been surpassed.

The United States' decline in economic competitiveness has closely followed the decline in federal funding for university-based research, which peaked in 1968. Although this correlation is probably more symbolic than causal, the fact remains that federal support declined from 1968 to 1980. Moreover, this decline in federal funding was so large that universities could not make up the difference. As a result, university-based research has seriously suffered.

"Cumulative neglect of university research has led to shortages of manpower, equipment, and facilities," notes Erich Bloch, director of the National Science Foundation (NSF). He cites the following dismal facts:

- We lack Ph.D. engineers to staff our universities. Since 1981 more than 50 percent of the engineering Ph.D.s awarded in this country have been to foreign nationals.
- Both Japan and the Soviet Union produce more engineers per capita than the United States.
- Federal spending in constant dollars on academic research, equipment, and instrumentation declined 78 percent from 1966 to 1983.
- Needed renovation of university research buildings and laboratories nationally is estimated to cost between $15 billion and $20 billion.
- Nonmilitary federal research funding is a smaller share of the GNP in the United States than in either West Germany or Japan.

Fortunately, the national research agenda is changing. There is a growing realization that our technological standing will continue to decline without the discoveries that come only from basic research.

In the fifties and sixties the emphasis was on military and space technology. In the seventies money went largely into health, environmental, and energy research. Today the concentration is on economic competitiveness, which in turn has focused attention on scientific research. Indeed, many people now regard competitiveness as a national-security issue on par with military preparedness. The national research agenda is "to remain at the leading edge of discoveries and to produce the technical personnel that the country needs," in Bloch's words. "Both are essential to our economic competitiveness and must be done even in times of fiscal stringency."

***Our technological standing will decline without discoveries that come from research.***

A consensus on the need for increased emphasis on scientific research is emerging. It is best set forth in the 1986 report of the White House Science Council Panel on the Health of U.S. Colleges and Universities. Named after panel chairman David Packard of Hewlett-Packard and Yale physics professor Allan Bromley, the Packard-Bromley report has been remarkably influential. In fact, it may well set the national research agenda for years to come. Already the Reagan administration has made a request to double the National Science Foundation's budget, from which grants will be made to university research. Next year that budget request will increase 17 percent.

The panels' first recommendation is that "the federal government make substantially greater investments in our centers of learning in the eighties and nineties than [it did] in the seventies."

However, these new resources will not simply be plowed into existing programs. Just as the motive for research funding has shifted, the type of research to be supported is changing. The report's second recommendation calls for "a major initiative to establish university-based interdisciplinary, problem-oriented research and technology centers directed at problems of broad national needs and relevant to industrial technology."

Research can no longer comfortably be confined to the boundaries of traditional disciplines. "These boundaries are breaking down. Some of the most exciting science is at the interface between established disciplines," Bloch writes.

No longer centering on the individual investigator, research is becoming more collaborative. New and exciting areas are increasingly interdisciplinary, requiring the combined efforts of a group of researchers. Another reason for such collaboration is that equipment and instruments are becoming extremely costly. Collaboration can help spread these costs across a number of researchers.

Bloch, who is emerging as the most influential science-policy spokesperson in the nation, is committed to the concept of multidisciplinary research centers. These centers will complement rather than supplant existing single-discipline research, for which $1.1 billion has been requested.

Just as the science and technology centers will require funding from a number of federal agencies, industry, and university sources, Packard-Bromley also recommends that awards from a new NSF fund to refurbish obsolete university laboratories be made on a 50-50 matching basis. This would require shared instruments and equipment with multiple funding sources.

While university-industry relationships must be structured with great care to protect the interests of both parties, the potential benefits of cooperation have never been greater.

It seems clear that we are on the verge of a renaissance in university-based scientific research. The changing nature of research, the demand for new knowledge, the need for trained scientists and engineers—all are being acknowledged at the highest levels of government and industry.

"In the eighties the clear national goal is maintaining and improving the competitiveness of U.S. industry in international trade," according to Slade Gordon, chairman of the Senate Subcommittee on Science, Technology, and Space. "If industrial and scientific leaders join together to advocate a specific R&D program, Congress will very likely enact it."

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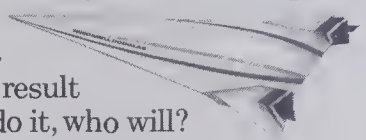

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